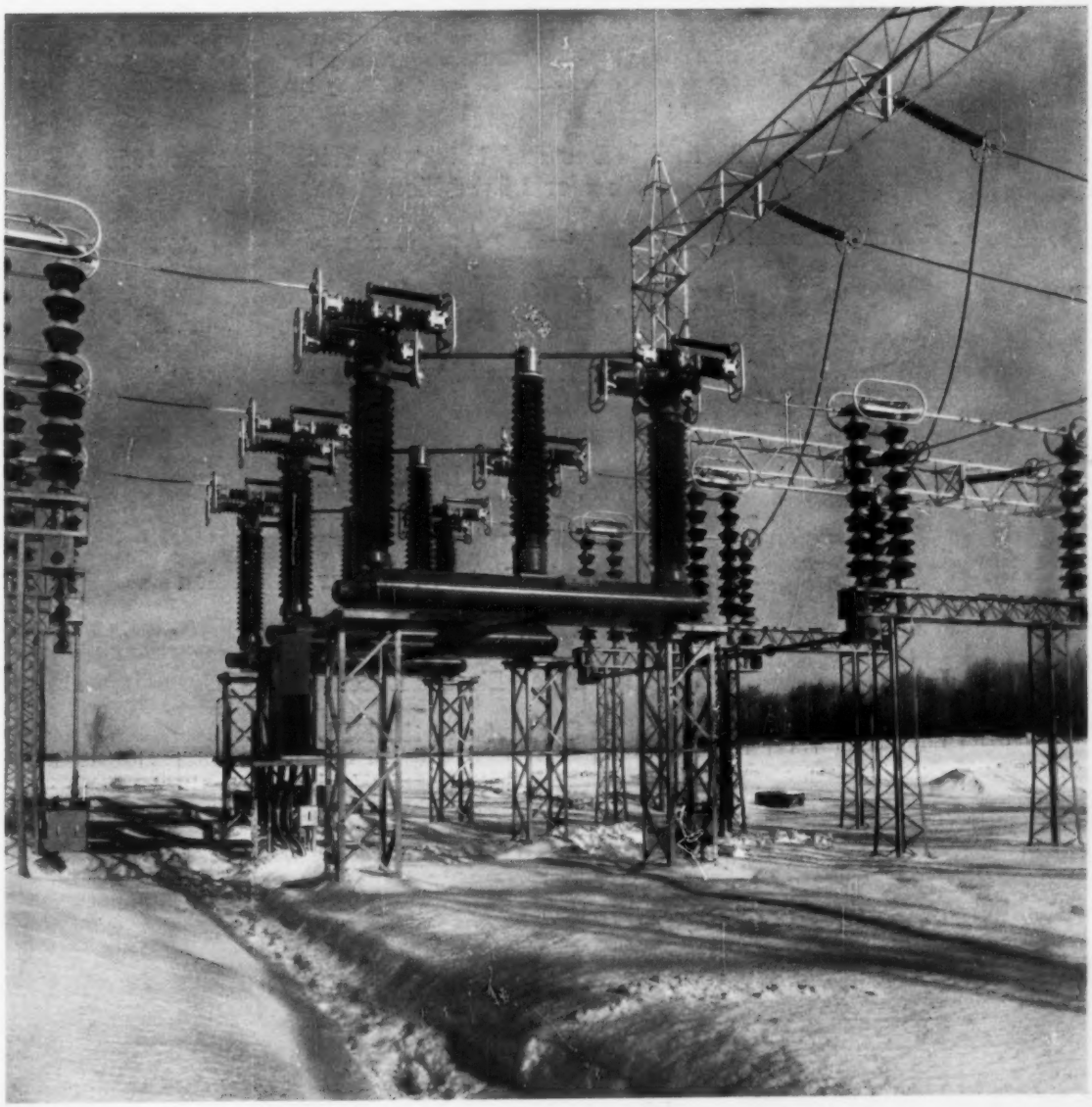
THE BEAMA JOURNAL

FEBRUARY 1959



British-built 300 kV air-blast circuit-breakers in Canada

A QUARTERLY REVIEW OF

BRITISH ELECTRICAL AND ALLIED ENGINEERING

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Editor: **Sam Black** *Technical Editor:* **John Dyer**

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A QUARTERLY REVIEW OF BRITISH ELECTRICAL AND ALLIED ENGINEERING

Volume 66 : Number 1 : February 1959

The British Electrical Industry in 1958

Brussels Retrospect

Among the many outstanding events of the past year, the Brussels Universal and International Exhibition will long be remembered.

In our last issue, which went to press just at the end of the Exhibition, we announced the news of the triumph of the British Electrical and Allied Industry's exhibit in securing no less than 15 medals, including 2 Grand Prix and 3 Diplomas of Honour. This issue includes a retrospect of the British representation at Brussels, with much information and many pictures not previously published in THE BEAMA JOURNAL.

Britain's Success at Geneva

Another notable British success was achieved in September at the Second United Nations Conference on the Peaceful Uses of Atomic Energy and its complementary exhibitions. Our report in the November 1958 issue emphasized the leading part which British scientists and engineers played in the Conference, and the predominance of the British Section in the Industrial Exhibition, with its theme of continued leadership in the nuclear generation of electricity and the production, application, and world export of radioactive isotopes.

Overseas Exhibitions in 1959

While there will be no great international events like Brussels and Geneva in 1959, the British Electrical and Allied Industry will tell its story overseas through individual or collective exhibits at the Hanover Trade Fair in the spring; at the Rand Easter Show in South Africa, and at the British Trade Fair in Lisbon from May 29 to June 14.

At Hanover there will be a collective exhibit organized by the Board of Trade with the cooperation of NETAC (the Nuclear Energy Trade Associations' Conference), of which the BEAMA is a founder member. NETAC organized the successful British Section of the 'Atoms for Peace' Exhibition at Geneva, and cooperated in the British exhibit at the two previous Hanover Fairs. The theme will again be Britain's leadership in the nuclear field.

Under the title 'Power for Progress' the BEAMA Southern Africa Overseas Committee will stage at the Rand Easter Show a collective exhibit portraying Britain's great contribution in the electrical field. There will be three sections: 'Power from the Earth', 'Power from the Hills', and 'Power from the Atom', and many of the prize-winning exhibits from Brussels will be shown.

The British Trade Fair at Lisbon is sponsored by the Federation of British Industries, and will be held in the new Exhibition Hall situated on the River Tagus. It will be the first foreign trade fair ever to be held in this hall.

British Progress in Computers

The International Scientific Symposium on the Mechanization of Human Thought at the National Physical Laboratory, and the Computer Exhibition and Business Symposium on Computer Applications at Olympia, London, at the beginning of December comprised the first event of its kind ever to be held in Europe. The unexpectedly large numbers and keen interest of the visitors to the exhibition, and the demand for tickets for both symposia (which exceeded the available accommodation), showed, in the words of the Exhibition Chairman, Mr Vernon Roberts, OBE, that 'the world is looking to Britain for leadership in this new field. This country is well able to give that leadership. Both from the point of view of technical advancement and the application of computer techniques to industry and commerce, Britain is already in a very strong position.'

The impact of the electronic computer on scientific research is by now well known; the full significance of its effect on the industrial, commercial, and economic life of highly developed countries is now becoming increasingly apparent. More than 100 computers are known to be operating in this country, and exports of British computers are becoming significant.

Britain's Lead in Electricity Generation

New generating capacity installed during 1958 amounted to 1230 MW in England and Wales, and 120 MW in the area of the South of Scotland Electricity Board—a total

of 1350 MW. These figures are lower than the totals for 1957, but the trend is in line with the programme planned five years ago, and takes into account the plant outstanding from earlier years and the Government's decision to give priority to export orders for power station plant.

The industry has been quick to respond, and exports of steam generating plant have shown an impressive increase. The total for 1958 reached the high figure of 1130 MW—some 24 per cent greater than the 1957 total of just over 910 MW.

The most important development, however, is that 1958 saw the commissioning of two of the largest generating sets yet installed in the UK—one in England and one in Scotland, and both of 120 MW capacity. The trend towards larger sets, with their accompanying higher generating efficiencies and lower costs per kW installed, is shown by the fact that, of twenty new turbogenerators installed last year, only four were of less than 60 MW; ten were 60 MW units, four were of 100 MW, and two were the 120 MW units just mentioned.

But even these will be dwarfed by the new machines now under construction. Two projected new stations in the North of England will each have a capacity of 550 MW, developed in one case by a 550 MW boiler supplying a 2×275 MW cross-compounded reheat turboalternator, and in the other by two 275 MW boilers supplying two 275 MW in-line (tandem compound) turbogenerators.

Both these sets are the largest of their kind, and the first is also the largest single unit on order, in the world. When one remembers that only about twenty years ago turbogenerators were commonly of about 30 MW capacity, one can measure Britain's tremendous advances and present leadership in the field of electricity generation.

Nuclear Power for Export

The foundation stone for the first of the nuclear power stations to be exported from Britain, and the first nuclear station in Italy, was laid in November last by President Gronchi at the site at Borgo Sabotino, near Latina. Designed to produce 200 MW of electricity, it is being built by the Nuclear Power Plant Co Ltd, one of the British consortia, at a cost of over £20 million, and is expected to start operating in 1962.

Japan is another centre of export interest. An agreement between the British and Japanese governments for cooperation in the peaceful uses of nuclear energy was signed last year, and it is expected that the contract for building Japan's first nuclear station will be placed during the next few months with one of the three British consortia who have tendered for this project.

The General Electric Co Ltd has also announced the conclusion of a manufacturing agreement with the Fuji Electric Co in anticipation of an order from the Japanese Atomic Power Generating Co, indicating that the first order referred to above may be followed by at least another one later in the year.

Big Telecommunication Projects

'In no branch of applied science—with the possible exception of the application of nuclear physics—has progress been more rapid during the past few decades' said Sir Gordon Radley, Director-General of the British Post Office, in his paper on 'Communication between Nations and between Peoples' at the British Electrical Conference at Brussels last May. He went on to say '. . . subscriber dialling to call any telephone within the national network is an objective in many countries. By 1970 three-quarters of all long-distance calls in the United Kingdom should be dialled by the callers.'

On December 5, HM The Queen in Bristol dialled the number of the Lord Provost of Edinburgh and inaugurated the first STD (Subscriber Trunk Dialling) system in Great Britain. It will be extended as rapidly as resources permit, and by the end of 1961 subscriber trunk dialling is expected to be available in over 100 centres.

The STD equipment at Bristol embodies new electronic apparatus, but electro-mechanical equipment giving the same facilities has also been developed and will be used in appropriate cases in future installations.

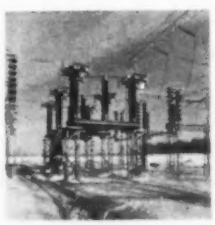
All this equipment has been developed jointly by the British Post Office and the five manufacturers who are the principal suppliers of telecommunication equipment. As the Postmaster-General recently pointed out, the development of new telephone equipment in this country has been the main reason for our large export trade in the telecommunication field.

We should also recall, for it assuredly belongs to the major events of 1958, the historic decision of the Commonwealth Trade and Economic Conference in Montreal to link Britain and the Commonwealth by a telephone cable which will literally encircle the world. It will be another ten years before this vast project can be completed, but the very fact that it can now be planned as a practicable proposition is in itself a tribute to British skill and experience in this field; to the technical knowledge and engineering resources of the firms who will manufacture the submarine cables, underwater repeaters, and associated equipment, and to the British Post Office, whose cable-laying ship *Monarch* is the only cable ship afloat capable of laying a cable in one operation across the deep section of the North Atlantic.

Railway Electrification

This, like many other electrical projects, must be a continuing operation extending over many years. Nevertheless, there occur from year to year certain events which mark a definite stage of progress, and one such event is recorded on page 30 of this issue.

This was the inauguration of the first 25 kV electric locomotive on the British Railways system, and although E 1000 (its official number) is a prototype and a conversion from an earlier experimental gas turbine locomotive, and some of its equipment differs from that of the new electric locomotives now being built for regular service, it has nevertheless made railway history in 1958.



Cover illustration. *The first British-built 300 kV air-blast circuit-breakers are now in service in Canada. This picture shows one of two type GA9W8S 7500 MVA Metropolitan-Vickers units at the Bout de l'Ile substation of the Quebec Hydro-Electric Commission. This type of breaker is particularly suitable for coping with the wide range of temperatures experienced in this region.*

British Electrical Industry's Triumph at the 1958 Brussels World Exhibition

THE Henry Moore sculpture of 'the world and his wife' was a very appropriate introduction to the British Industry Pavilion, since, of the 42 million people who attended the 1958 Brussels World Exhibition, over 5 million visited the British section.

The Brussels Universal and International Exhibition, 1958—to give it the official title—celebrated the centenary of international cooperation in exhibitions, the first world exhibition having been held at the Crystal Palace in 1851. The previous international exhibitions were held at New York in 1939, in Paris 1937, and at Brussels in 1935.

The 1958 Brussels Exhibition—coming after an interval of nineteen years in which remarkable technological progress had been made—presented the Belgian authorities with a wonderful opportunity to stage the finest exhibition ever to be held. The record tells how well the Belgians rose to the occasion.

The British Government pledged its full support to the Exhibition at a very early stage and it was decided to have two pavilions in the British section—one to depict the British way of life and a second, larger pavilion to be devoted to an exposition of British industry. The

Government voted a sum of about £400,000 for the National pavilion and invited the Federation of British Industries to organize the Industrial pavilion.

The FBI sought the views of representatives of all sections of British industry and was sufficiently encouraged by the support shown to undertake this onerous responsibility. The British Electrical and Allied Manufacturers' Association was one of the first trade associations to promise support, and the unstinted cooperation of the British electrical industry undoubtedly proved a major factor in the successful achievement of the British Industry Pavilion.

The original plan drawn up by the FBI envisaged a thematic treatment of the story of British industry; starting with raw materials, power, engineering, industrial processes, leading up to a final section of consumer goods. This plan was an excellent one, but it depended for its success on the participation of all the appropriate trade associations.

The BEAMA Council decided that the British Electrical and Allied Industry must play its part in the preparation of this 'shop window on the world' and committees were set up as early as 1955 to discuss the form that the Industry's collective exhibit should take. The plan adopted was fully in accordance with the FBI original brief and told the story of electricity in the service of mankind.

A Great Collective Enterprise

While the BEAMA—joined by the Water-Tube Boilermakers' Association, the British Radio Equipment Manufacturers' Association, the Cable Makers' Association, the Electric Light Fittings Association, the Electronic Engineering Association, and the Telecommunication Engineering & Manufacturing Association—proceeded with its plan, most other sections of British industry turned a deaf ear to the appeals from the FBI and the Board of Trade to support the British Industry Pavilion at Brussels. As a result, many of Britain's staple industries were missing from the Pavilion, and in fact more than one-third of the Pavilion was devoted to electrical and nuclear engineering exhibits.

The great success of the parts of the British Industry Pavilion which were organized on a thematic basis was ample justification for the FBI's original plan, and BEAMA was more than satisfied with the results of the British Electrical and Allied Industry collective exhibit. Throughout the six months this stand was a focus of attention, and the award by the Belgian authorities to the exhibit of 2 Grand Prix and 13 other medals set the seal on the Industry's successful participation at this 1958 Brussels World Exhibition. The award of 15 medals to one single exhibit is probably a record for international exhibitions and is a mark of the excellence and comprehensive nature of the stand, which was the largest single exhibit from Britain.

Nearly 200 separate companies supported this collective exhibit, but all sunk their own identity except for the acknowledgment boards on the stand. All the exhibits and models were anonymous and chosen solely for their contribution to the story of the Industry. All the organization and administration of the exhibit was carried out by a representative organizing committee.

Britain's Great Success

The British Section at Brussels opened on time and right from the first day proved an outstanding success.

The awards by the International Jury of a Gold Star to the Government Pavilion and Silver Stars to the British Industry Pavilion and the City of London Pavilion were richly deserved. The unofficial placing of the Government Pavilion as third out of all the pavilions was warmly welcomed and would be agreed by most people who visited the Exhibition. The Czechoslovakian Pavilion was judged first and the Belgian Civil Engineering Pavilion was placed second.

Official Commendation

The following extracts are quoted from the letter of congratulation sent by Mr Selwyn Lloyd, Secretary of State for Foreign Affairs, to Sir John Balfour, UK Commissioner General:

'Our success has been due not only to the inspiration of the main design but also to the ready cooperation of those who directly serve the Government and those who pursue an energetic course in the promotion of British industry and commerce. We have every reason to be confident in their achievement when we see this example of their work.'

The Royal Visitors

High-lights from the Exhibition diary were the visits of HRH the Duke of Edinburgh in July and of HRH Princess Margaret during the last week of September. A week later the stand was honoured by a lengthy visit from HM King Baudouin of the Belgians, who inspected all the exhibits with great interest.

Other royal visitors during the run of the Exhibition included HRH The Duke of Kent; HRH Prince William of Gloucester; HM Queen Elizabeth of Belgium; SAR Le Prince de Liège; HM The Queen of the Netherlands; TM the King and Queen of Greece; Princess Birgitta of Sweden; TRH the King and Queen of Nepal; The Heir Apparent of Bahrein.

Among many other distinguished visitors from overseas countries were: M. Polacek, Deputy Premier of Czechoslovakia; M. Paul Struye, President of the Belgian Senate; M. Gaston Eyskens, Prime Minister of Belgium; Dr Adenauer, Chancellor of the Federal German Republic; Mr T. Drouin, Speaker of the Canadian Senate; Mr Shangiti, Speaker, of the House of Representatives, Sudan Parliament; Mr Chizhov, Deputy Minister of Power Stations, USSR; Dr Tom Ingledow, President, British Columbia Electricity Corporation, Vancouver; Dr J. Dorofeet, Academy of Sciences, USSR; Mr J. M. Magowan, Chief Electrical Engineer, Electricity Supply of Southern Rhodesia; The Minister of Commerce, Iran.

The Verdict of the World's Press

The British section was praised in the world's press from the *New York Herald Tribune* and the *New York Times* to *Il Giornale d' Italia* (Rome), *Die Zeit* (Hamburg), and even in *Pravda* (USSR).

Special Brussels Publications

It was considered desirable to have a publication giving general information about the achievements of our In-

dustry, and therefore a special souvenir book *Serving the World* was produced by BEAMA. Of the 50,000 copies, half were sent overseas early in 1958 together with a multi-lingual supplement and an invitation to recipients to visit our Industry's stand at Brussels.

100,000 copies of a book *Electricity in the Home*, giving details in three languages about British domestic electrical appliances, were distributed in the Domestic, Radio, and Television Section at Brussels.

In addition to these comprehensive publications, several of the supporting associations produced their own multi-lingual publications. The Water-Tube Boilermakers' Association published a book entitled *Steam Power*; the Telecommunication Engineering & Manufacturing Association's book was *Leadership in Telecommunications by Great Britain*; and the Electronic Engineering Association published a book giving detailed information about the British electronic engineering industry.

In addition leaflets were available dealing with specialized subjects such as nuclear energy. Visitors to the stand were able to refer to current issues of the leading electrical ournals.

The BEAMA Catalogue

BEAMA publishes one of the most comprehensive trade catalogues in the world, and 15,000 copies are sent to overseas buyers. It normally appears every four years, but the fourth edition was published early in 1958 in order that copies should be available for the opening of the Brussels Exhibition.

The Catalogue has 936 pages and includes a five-language glossary and buyer's guide, and a very comprehensive trade directory. The catalogue has three main sections:

(*a*) Electrical Power Plant;
(*b*) Electrical Equipment in Industry, Transport, and Communications;
(*c*) Domestic and Commercial Electrical Appliances, Lighting Accessories, and Installation Material;

and for the Brussels Exhibition these three sections were bound separately as supplementary volumes in addition to being included in the Catalogue. Many thousands of these separate sections were presented to trade buyers who visited Brussels during the six months of the Exhibition.

Looking Ahead

And so the Exhibition came to an end on 19 October, having proved the most successful of all International Exhibitions that have been held since the first one at the Crystal Palace in 1851. Its results cannot yet be fully assessed. The impressions of Brussels will remain in the minds of the millions who visited it for a long time to come and will inevitably influence their thinking. In no other way could Britain have made personal contact with so many people and left such a lasting impression.

Soon the demolition squads moved in and the scene was transformed. Some of the national pavilions were prepared for transportation home where they will find a use as museums, schools, and hospitals. The British Government Pavilion will live again in March 1959 at the Ideal Home Exhibition at Olympia, where the major part of the Pavilion will be re-erected to form the central feature of the Exhibition. The British Industry Pavilion has been sold to the Dutch city of Hilversum, where it will be used as a sports stadium and concert hall.

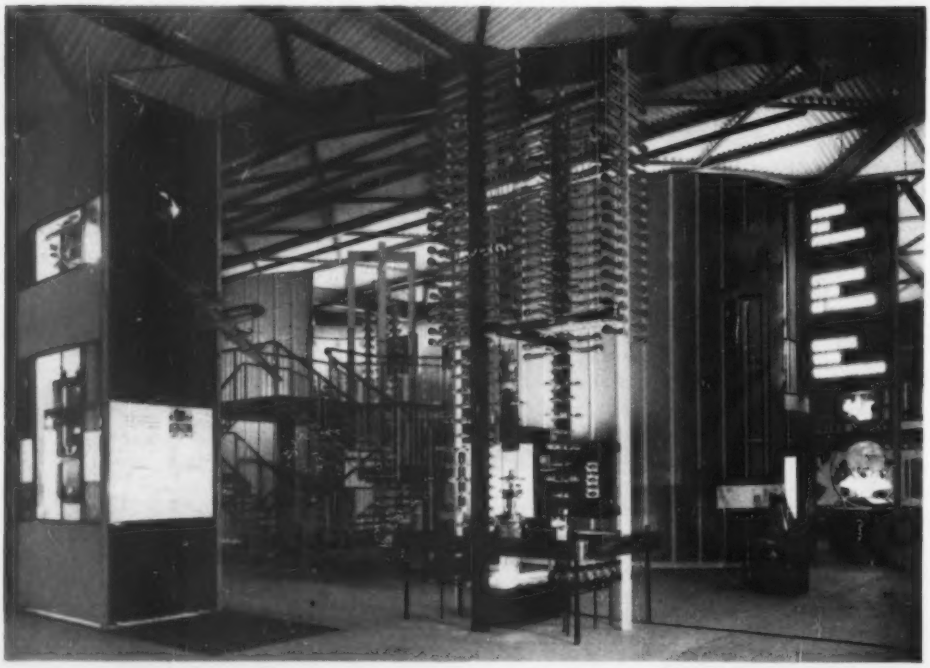
The exhibits and models of the British electrical exhibit were soon brought back to this country, but they were not entirely dispersed, for many of the items are now on their way to Johannesburg where they will form the basis of the collective electrical exhibit which is to be staged by the BEAMA Southern Africa Overseas Committee at the 1959 Rand Easter Show.

BRITISH ELECTRICAL AWARDS AT BRUSSELS

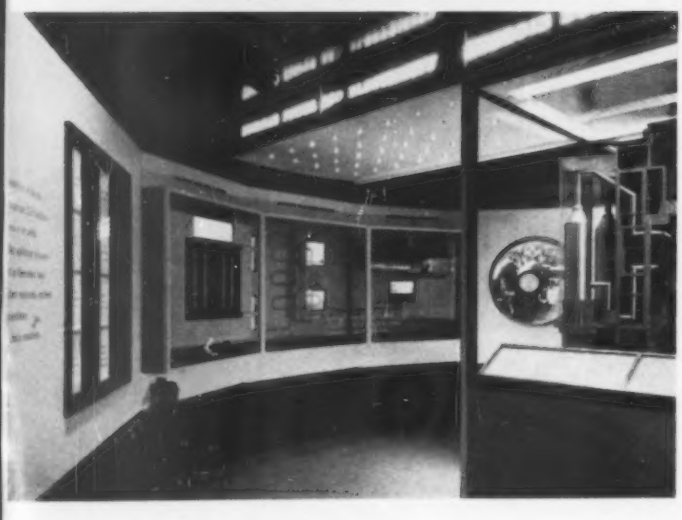
2 Grand Prix
3 Diplomas of Honour
3 Gold Medals
3 Silver Medals
4 Bronze Medals

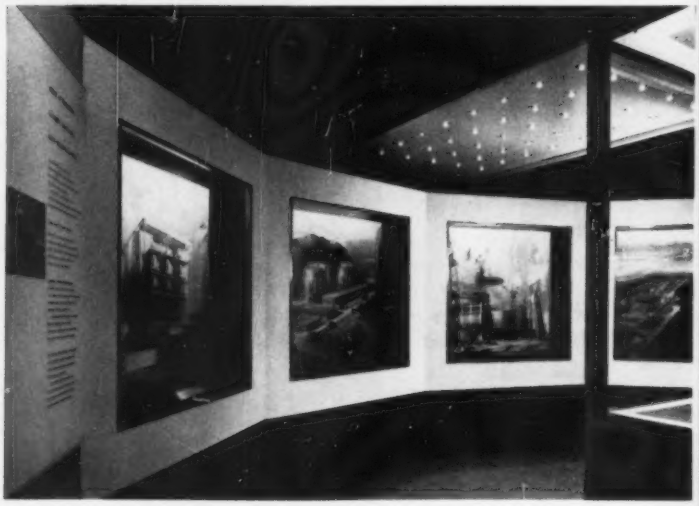
VIEWS OF THE BRITISH ELECTRICAL AND ALLIED INDUSTRY'S EXHIBIT

The top picture on this and the facing page show two murals designed to symbolize the benefits which electricity brings to the most remote corners of the world, from the Arctic to the Equator. The backgrounds illustrate a nuclear power station and a hydro-electric installation respectively
The centre picture on this page is a view of the valve tower, comprising over fifteen hundred valves and transistors symbolizing the British electronics industry. Beyond it to the right, a radar scanner turns continuously and a viewer shows how Southampton Water would appear on the radar equipment on the ship's bridge. In the left foreground is a model of the new Bristol Britannia aircraft with a display emphasizing the vital part electricity plays in the airliner's flight

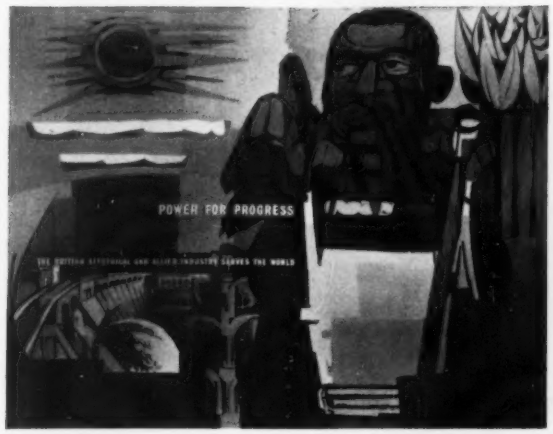


The pictures below are two views inside the second Chamber of Energy, which was devoted to nuclear power. The pictures give a striking impression of the four new nuclear power stations now under construction in Great Britain and scheduled for operation during 1960–62



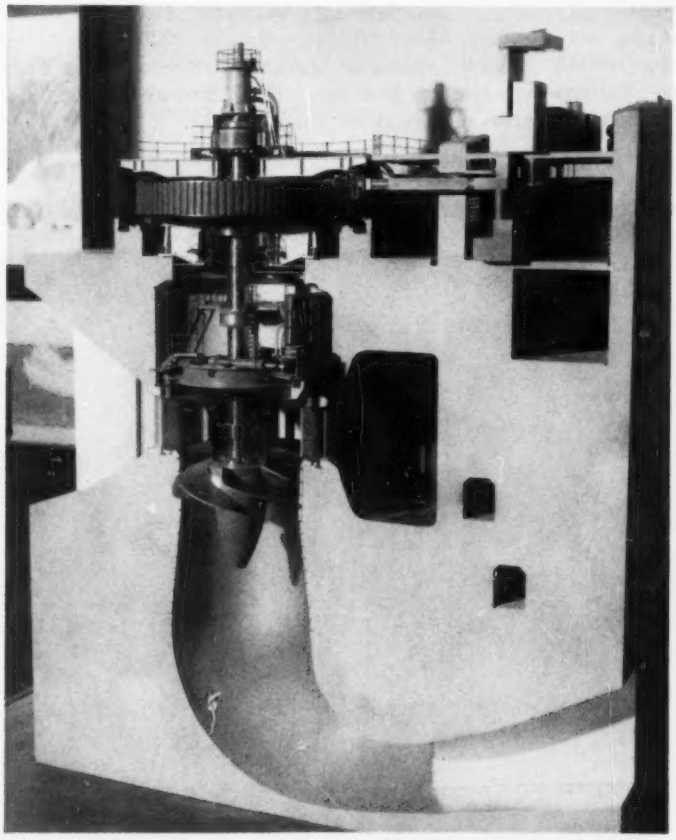


WORLD



(Below) *View from the top of the staircase to the Domestic Section. Immediately on the left is a high voltage glass insulator. On the right, the beginning of the cooker section and beyond it the Inquiry Office and the other parts of the Domestic Section*

The lower left picture shows a working sectional model of a complete hydro-electric set as supplied by a British firm to the USA for the Priest Rapids hydro-electric scheme. On the right is a close-up of the very large propeller runner, which was slowly revolving above the heads of visitors to the Chamber of Energy devoted to water power



British domestic electrical appliances attracted much attention. Below are seen some of the interpreters and demonstrators on duty at the stand

Some young visitors from Holland in national costume

Description of the British Electrical and Allied Industry Exhibit at Brussels

THE exhibit was designed to present a comprehensive picture of the Industry's great contribution to the service of mankind. It was the largest single exhibit from Britain. Approximately half the area was built-up to a height of over 20 feet (6·1 m), providing a considerable amount of 'first-floor' accommodation, raising the effective floor area to approximately 6500 square feet (604 m²).

Chambers of Energy
Along one side of the exhibit area were the three Chambers of Energy which, together with the connecting links between the chambers, formed an arresting pattern of structures which immediately attracted the notice of visitors entering the British Industry Pavilion. Each of these cylindrical chambers was about 20 feet (6·1 m) in diameter with a 70 feet (21·3 m) long walk through the three. On the outside walls of the Chambers of Energy were two large murals, 11 feet by 9 feet (3·4 m by 2·7 m) each, depicting the contribution of electricity to the advancement of mankind.

The Thermal Power Chamber
On the right-hand side of the first chamber were three scale models; a coal-fired boiler unit of the type installed at the new High Marnham power station, an oil-fired boiler, and a Calder Hall type heat exchanger. On the left side was a large three-dimensional flow chart illustrating the conventional thermal method of generating electricity. In the first link, on the way to the second chamber, was a model of a steam power and industrial installation on one side, and a turbo-alternator working model on the other side.

The Nuclear Energy Chamber
Sound effects were used to tell the world in many languages that 'Britain Leads in this Atomic Age'. A cut-away model of the reactor of the power station under construction at Hunterston, in Scotland, dominated the centre of the chamber. On the left-hand wall were three-dimensional displays, showing how nuclear energy is turned into electricity in Britain's nuclear power stations. Four oil paintings by Claude Buckle showed the new nuclear power stations under construction in Britain: Bradwell, Berkeley, Hunterston, and Hinkley Point. Also on show was a special model of 'Sceptre III'—the thermo-nuclear experimental apparatus at Aldermaston.

The Water Power Chamber
In the link before the third chamber a diorama demonstrated how nuclear power stations could be employed continuously at full load by coupling them with a pumped storage hydro-electric station. Opposite to this, two powerful jets of water spun a Pelton Wheel, while a stroboscopic lamp showed the reaction of the water against the cups on the wheel. This assembly is normally used by engineers for research on reaction turbines. In the centre of this chamber, a very large propeller runner, about 18 feet in diameter, turned above the heads of the visitors. This impressive centrepiece was supplemented by an animated sectional model of a hydro-electric set illustrating how the propeller runner is used in practice, as at the new Priest Rapids scheme in the USA. In addition, an extensive photographic display depicted British generating plant used throughout the world.

Transmission and Distribution
In the spacious courtyard in the centre of the Stand, the story of transmission and distribution was told by a variety of items of equipment and models. These included: an air-cooled circuit-breaker installation display; a model of one of the Central Electricity Generating Board's new control centres; and a large layout showing how electricity leaves a power station, is transmitted through the Grid and transformed for the use of different types of consumers in homes, factories, offices, and on the land. A single-phase 275,000 volts oil-filled circuit-breaker dominated the far corner of the stand and the whole pavilion façade. In this section there was also a three-dimensional display of cables arranged with the cooperation of the Cable Makers' Association.

Electric Traction
Electric traction for road, rail, sea, and air was prominently displayed. An overhead gantry carried a number of sets of railway signal lights which operated in an appropriate sequence. A large model of the new P & O all-electric liner *Canberra*, which is at present being built at Belfast, demonstrated the extent to which electricity is used at sea. This model was flanked by a number of telephones giving information in three languages about the ship. A special model of a Bristol 'Britannia' aircraft emphasized the importance of electricity in the air. A massed display of electric and diesel-electric locomotive models in the liveries of many countries called attention to the world-wide markets for British locomotives. Photographs illustrated other aspects of electric road and rail traction.

Electricity in the Service of Industry
Space did not allow the actual demonstration of any electrical industrial processes, but the extent to which practically all basic industries are dependent on electricity for modernization and efficiency was high-lighted by an animated display of photographs 'Electricity serves Industry from A-Z'. Photographs of furnaces, welding, and other industrial electrical processes were also shown.

Electronics and Radio Navigation
Britain's prominent part in the invention and development of radar and electronics was stressed by a special 18 feet (5·5 m) high Valve Tower made up of over fifteen hundred valves and transistors of British manufacture which are used internationally in industry, medicine, communications, scientific research, and in the home. A working exhibit of a marine radar scanner linked to a viewer display which simulated actual working conditions in Southampton Water completed the electronics section.

The Domestic and Radio Section
On the first floor of the Chambers of Energy and their connecting links, an attractive lounge provided a suitable setting for a representative display of British domestic

electrical appliances, and radio and television receivers. This exhibit, which covered 900 square feet (83·6 m²), was supported by 28 firms displaying 80 different products.

Overseas Development Schemes

Throughout the exhibit, captions and pictures emphasized the part that the Industry has played in overseas development. In a special section, six typical overseas schemes carried out by British engineers and manufacturers showed how Britain is 'Serving the World'. The features chosen—from the very many considered—were the Owen Falls scheme; the Vancouver undersea power link; the Lisbon–Oporto telephone system; railway electrification in Brazil; a feature depicting British transformers *en route* to the Tennessee Valley Authority; and a special skip-winding mining feature. Adjacent to this overseas section was a large three-dimensional map of the world showing where £1000 million value of exports from the Industry have been supplied in the last four years. Here, too, poster display served to emphasize that Britain has led the world in the development and use of electricity from Faraday to Calder Hall, and onward to the investigation of nuclear fusion for peaceful purposes.

Lighting of the Exhibit

As befitted an exhibit staged by the electrical industry, full use was made of modern methods of lighting to illuminate the exhibits and to provide additional decorative effects where appropriate.

General Features of the Exhibit

A series of three large glass bulb rectifiers, lightly activated; a display of water-tubes symbolizing steam power; the large circuit-breaker; the valve tower and the radar scanner gave visitors to the exhibit a sense of size and prevented any possibility of the feeling of miniaturization which could so easily have resulted from a collection of scale models.

A large panel on the outside wall of the Technical Inquiry Office bore the names of the associations and firms supporting the collective exhibit and this list was repeated inside the office. All the actual exhibits and models shown were anonymous, except in the Domestic and Radio Section where the individual items were captioned.

The exhibit was designed by Design Research Unit under the direction of Misha Black, OBE, RDI, PPSIA, MINSTRA, and Kenneth Bayes, FRIBA, MSIA. The contractors were F. W. Clifford Ltd.

Technical Inquiries

One complete corner of the exhibit consisted of the Technical Inquiry Office block. Here, on the ground floor, an efficient staff of interpreters and engineers, speaking between them ten languages (provided on a rota by member-firms), dealt with all inquiries, and here visitors could read technical journals and consult electrical books of reference. On one inside wall of the office was a display of oil paintings lent by the Telecommunication Engineering & Manufacturing Association, entitled 'British Leadership in Telecommunications'. The four paintings, by Francis B. Savage, depicted notable British 'firsts' in this field.

Above this office there was a comfortable lounge for receiving visitors and answering inquiries.

It was very clear that the Industry's exhibit at Brussels needed adequate staffing if the maximum benefit was to be derived. Accordingly careful plans were made and the help of all firms in the Industry was sought.

The staff consisted of 3 categories—interpreters, technically qualified engineers, and young ladies for the Domestic Section. Thanks to the ready cooperation of BEAMA member-firms and the other supporting trade associations, there was a rota of 7 engineers on duty throughout the period of the Exhibition. This allowed 4 engineers to be available at any time as the Exhibition was open seven days a week. These engineers covered between them a comprehensive knowledge of the Industry and most of them spoke 2 or 3 foreign languages fluently. With the additional assistance of the interpreters it was possible to answer questions in ten languages. The young ladies—in their distinctive blue tailored cotton dresses—were mainly employed in the Domestic Section and they were chosen for their knowledge of languages allied to natural charm.

At no time was the staff at a loss to answer inquiries in any language, and on a number of occasions help in interpreting was given to other stands in the British Industry Pavilion.

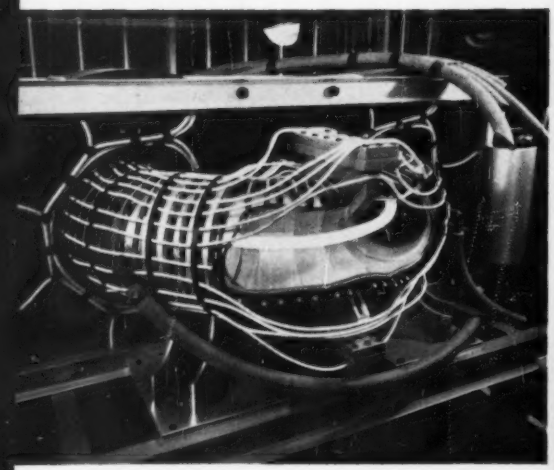
The staff was equipped with an excellent reference library and most questions were answered on the spot. Inquiries requiring more detailed replies, however, were recorded on specially designed inquiry forms and sent immediately to BEAMA headquarters in London where the requests were relayed to all supporting firms and associations. Urgent requests for information were sent to London by telex. The following analyses cover 927 inquiries from 51 different countries and illustrate the diversity of interest.

Class of Inquirer	Number	Per cent of total
Government Departments, Public Utilities (Electricity, etc)	85	9
Manufacturing, Mining, and Commercial Companies	186	20
Agents, Importers, Wholesalers, and Retailers	116	13
Associations, Institutions, and Learned Bodies	98	11
Domestic and Private	442	47
	927	100

Nature of Inquiries	Number	Per cent of total
Power Plant and Associated Equipment	118	13
Nuclear	9	1
Generation (Steam, Hydro, and Oil)	27	3
Transformers and Switchgear	34	4
Transmission and Cables	26	3
Rectifiers and Converters	17	2
General	5	—
Industrial Apparatus and Equipment	224	24
Automation and Process Control	29	3
Motors and Rotating Machines	18	2
Welding and Heat-treatment	10	1
Transport	43	5
Instruments	20	2
Electronics, Radar, and Telecommunications	45	5
General	59	6
Domestic and Commercial Appliances and Equipment	553	60
Appliances (Heating, Cooking, etc)	256	28
Lighting	39	4
Radio and Television	104	11
Recorders (Tape and Disc)	116	13
General	38	4
Unclassified	32	3

BRITAIN GAVE THE WORLD STEAM POWER
LA GRANDE BRETAGNE DONNA AU MONDE LA FORCE DE LA VAPEUR
GROOT BRITTANNIE GAF AAN DE WERELD DE STOOMKRACHT

These three panels demonstrated that Britain gave the world steam power through the work of Watt, electricity through the work of Faraday, and now leads in the provision of electrical power from nuclear energy



At Aldermaston, research on thermo-nuclear fusion on Sceptre III supports the research programme of Zeta at Harwell. This working model attracted considerable interest at Brussels

(*Right*) These three mercury glass bulb rectifiers made a striking corner feature to the exhibit. The main title of the exhibit 'Power for Progress' can be seen above in English, French, and Flemish

At night, the crystalline spires of the British Government Pavilion made a wonderful sight

The 'Perspex' coat of arms at the entrance

The above photograph depicts the entrance to the Hall of Tradition. This led into the Hall of Technology where many British achievements in the field of science were shown. Dounreay, Jodrell Bank, and Zeta headed a wonderful display of British advances in medicine, engineering, aircraft, and biology

The Commonwealth Courtyard flying the flags of all the countries of the Commonwealth

THE BRITISH GOVERNMENT PAVILION

The display of regalia, heraldic motifs, ceremonial dress, and national flags illustrated traditional aspects of British life.

The outside courtyards showed the life of the people and many of the inventions originated in Britain

A fine view of the Hall of Tradition

THE NATIONAL DAYS AT THE EXHIBITION

ABOUT fifty nations participated in the Exhibition, and the visitors included men and women from every country in the world. It was this international atmosphere that made the occasion so memorable, and it was in the bringing together of so many different people that the main benefit came.

The countries participating were: Argentina, Austria, Belgium, Belgian Congo and Ruanda-Urundi, Brazil, Cambodia, Canada, Czechoslovakia, Egypt, Iraq, Jordan, Saudi Arabia, Syria, Finland, France, Germany, Holy See, Hungary, Iran, Israel, Italy, Japan, Liechtenstein, Luxembourg, Mexico, Morocco, Monaco, Netherlands, Nicaragua, Norway, Philippines, Portugal, San Marino, Spain, Sudan, Switzerland, Thailand, Tunisia, Turkey, Russia, America, United Kingdom, Venezuela, Yugoslavia, Dominican Republic. In addition the following international organizations exhibited: United Nations, European Coal and Steel Community, Organization for European Economic Cooperation, Council of Europe, Benelux, and the International Red Cross.

During the period of the Exhibition, special days were allotted to the nations taking part on which each country's culture, art, and scientific achievements could be featured.

Belgium made a wonderful effort to ensure that all visitors to the country during the Exhibition should receive a warm welcome and all Belgians were encouraged to be hospitable to visitors and to speak to them in their own language whenever possible.

This young lady was one of the senior official Exhibition hostesses who acted as guides and interpreters

The final gesture that the Belgian authorities made was to completely remodel the traffic system of Brussels. The fine new tunnels and overhead roads were greatly appreciated by all motorists.

The British Days at the 1958 Brussels World Exhibition were celebrated on 10, 11, 12 July in glorious sunshine. The high-light of the occasion was the visit of HRH the Duke of Edinburgh, who arrived by air on the morning of Thursday 10 July and stayed in Brussels until the morning of Saturday 12 July.

The visit of the Duke of Edinburgh to Belgium was an unofficial one, but he stayed with King Baudouin at the Royal Palace of Laeken and was received with all the ceremony and dignity appropriate to his position. He was met at the airport by SAR Le Prince de Liège, the brother of King Baudouin, and Le Prince de Liège accompanied the Duke at all the official functions throughout the visit.

The Duke of Edinburgh visits the British Section

On the afternoon of 10 July the Duke of Edinburgh and Le Prince de Liège paid an official visit to the British section. After visiting the British Government Pavilion he spent over one hour touring the British Industry Pavilion. At the conclusion of this tour the Duke paid a fleeting visit to the Britannia Inn, and then inspected the British Legion in front of the British Industry Pavilion.

The Duke's route through the British Industry Pavilion was planned in such a way that he visited all the stands, and he spent nearly ten minutes at the British Electrical and Allied Industry collective exhibit.

The Duke's party was followed by another distinguished group led by SAR Le Prince de Liège and high-ranking Belgian personalities. The first two parties were followed by many well-known personalities from Britain, led by Mr F. J. Erroll, Economic Secretary to the Treasury. During his detailed inspection of the exhibits in the British Industry Pavilion, the Duke of Edinburgh made many comments which suggested that he was favourably impressed by the show that British Industry was putting on at this world prestige occasion.

The British Government and the Federation of British Industries joined in giving a luncheon on Friday 11 July which was honoured by the presence of the Duke of Edinburgh and Le Prince de Liège. This was held at the Palais de L'Elégance in the Exhibition grounds, and staged with all the tradition and ceremony that is customary at British functions of this kind. The 500 guests included many distinguished Belgian and foreign dignitaries among whom were M. Gaston Eyskens, Prime Minister of Belgium, and M. Paul Struye, President of the Belgian Senate. Many of the heads of British firms associated with the Exhibition had come over to Belgium specially to attend the luncheon. This was a very fine Anglo-Belgian occasion and one which should further friendly relations.

During the British Days the cultural programme included concerts by the BBC Symphony Orchestra, the Huddersfield Choir, and the Band of the Scots Guards.

On 12 July, Sir George Labouchère, HM Ambassador to Belgium, unveiled a plaque in memory of the Guards' heroic conduct at the Battle of Waterloo.

Ultrasonics—The Application of Sonic Waves to Industrial Purposes

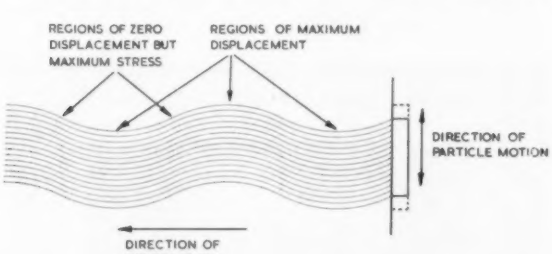
R. FOSKETT, BSc*

Introduction

DURING the past quarter of a century there has grown up a new family of industrial techniques employing sound waves in a variety of ways. Knowledge of the fundamental phenomena underlying these techniques has sprung in many cases from pure research which was not directed towards any immediate application. Subsequent development has brought to perfection a number of valuable industrial tools; others are still being evolved.

For the purpose of presenting an outline of the present position it is convenient to divide the field of application of sonic waves into two areas. The first of these contains the 'processing' applications. The acoustic wave is here employed to carry out active work or to initiate or accelerate some change in the properties of the processed material. The second area of application contains a variety of inspection and testing techniques in which the acoustic wave is used to provide information about the properties of materials or components.

Before examining the available techniques in any detail it may be useful to look briefly at the properties of sound waves and to define some of the terms we shall use. Sound is transmitted through a solid, liquid, or gaseous medium by elastic waves; these may be of several types. For example, the medium may vibrate in a compressional mode (the manner of transmission of ordinary sound in air), in a shear mode (the particles of the medium moving at right-angles to the direction of propagation), or a torsional mode (as along a long thin rod if one end is suddenly twisted). Sound can normally be propagated in fluids only in a compressional mode. These modes of propagation are illustrated in Fig 1. Surface waves, like the ripples on a pond, may also occur.


REGIONS OF ZERO DISPLACEMENT BUT MAXIMUM STRESS
REGIONS OF MAXIMUM DISPLACEMENT
DIRECTION OF PARTICLE MOTION
DIRECTION OF PROPAGATION

The frequencies of sound waves which may be detected by the average human ear lie below 16,000 cycles per second. Frequencies higher than this are known as ultrasonic. Such frequencies—up to some millions of cycles per second—are particularly useful in industry, so much so that the term 'ultrasonic' has come to be applied loosely to any process involving sound waves.

* Mullard Research Laboratories.

The particular value of these high frequencies in industrial work lies largely in two properties which they possess. Frequencies in the range of 10 kc/s to 1 Mc/s are able to produce in liquids the phenomenon known as cavitation. This is the formation within the liquid of bubbles of dissolved gas which subsequently vibrate and collapse, giving rise to shock wave pressures of many atmospheres. (The bubbles are produced when the instantaneous pressure in the liquid falls below the vapour pressure of the liquid, and normally quite substantial sound intensities are required for their initiation.) These large shock pressures produce powerful erosive and disruptive effects which are utilized in ultrasonic cleaning, emulsifying, and so on.

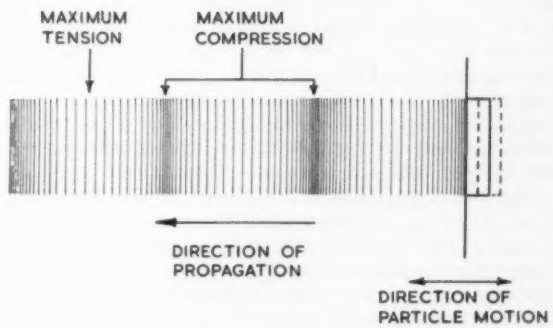
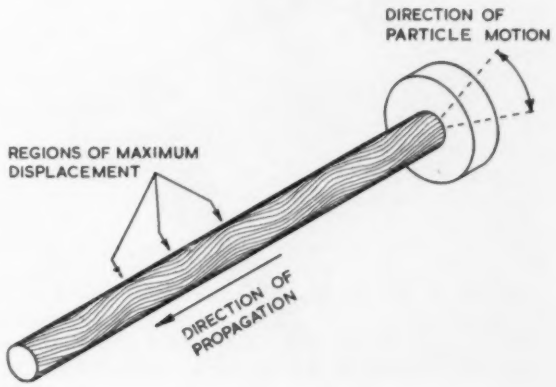


Fig 1. (Left) *In the propagation of a compressional elastic wave, the particles of the medium vibrate in a direction parallel to the direction of propagation*

(Above) *The particle motion in the shear mode is perpendicular to the direction of propagation*

(Below) *Torsional vibrations can exist in a slender rod; the rod oscillates about its lengthwise axis*



The second property of particular importance is most evident in sound waves of frequencies of 1 Mc/s and above. Such sound waves may be 'beamed' like light and also be reflected and refracted in a similar manner. They may thus be used to look into solid materials to find flaws, just as visible light might be used to examine a diamond. The relative transparency of materials to the sound and the manner in which it is reflected and refracted give information about the elastic properties and homogeneity of the materials.

Methods for generating acoustic waves are numerous, but for practical purposes only three are of importance.

(1) Whistles, in which the process liquid or gas is pumped through an orifice and made to vibrate by impinging upon a blade[1] or by passing a resonant cavity. These may be employed only with fluid media.

(2) Magnetostrictive transducers,[2] which are made of certain types of ferromagnetic materials. These possess the property of changing their dimensions when placed in a magnetic field. An alternating field is produced by passing current from a high frequency electrical generator through a coil surrounding the transducer. This causes the transducer to vibrate in sympathy. Extremely rugged, these transducers are used in many applications at frequencies up to 100 kc/s.

(3) Piezo-electric[3] and electrostrictive transducers are made from materials which respond to an electric field in a manner similar to that in which the magnetostrictive materials respond to a magnetic field. Suitable materials are quartz, barium titanate, or lead zirconate. Considerably more fragile, they are employed at higher frequencies, mainly above 100 kc/s, where magnetostrictive transducers are impracticable. These types of high frequency sound generators are illustrated in Fig 2.

The electrical generators employed to drive the magnetostrictive and electrostrictive types of transducer are generally of the hard thermionic valve type. Usually they comprise an oscillator driving an output stage, but sometimes they consist merely of a large power valve used as a self-oscillator. In some high-power applications requiring several kW at relatively low frequencies, say below 25 kc/s, rotary alternators have been used.

Cleaning and Processing

Probably the most publicized application of ultrasound is ultrasonic cleaning.[4] Quite remarkable results have been achieved in a wide variety of applications, great improvements upon conventional methods being obtained in respect of both speed and resultant cleanliness. The most striking results are obtained in the case of small intricate articles such as miniature ball-bearings, watch components, radio valve parts, etc. Recent work has, however, led to the extension of these techniques to much bulkier components, such as hydraulic valve bodies and castings prior to plating, outstanding improvements being effected in this field also. In principle the components to be cleaned are immersed in a suitable solvent which is brought into a state of cavitation by irradiation with high intensity sound waves. The frequency employed is not normally above 1 Mc/s. The cavitation loosens the dirt particles which are then washed away by the solvent. At the higher frequencies it seems likely that the high

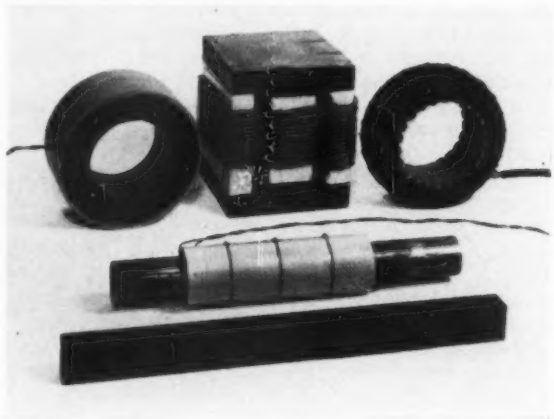
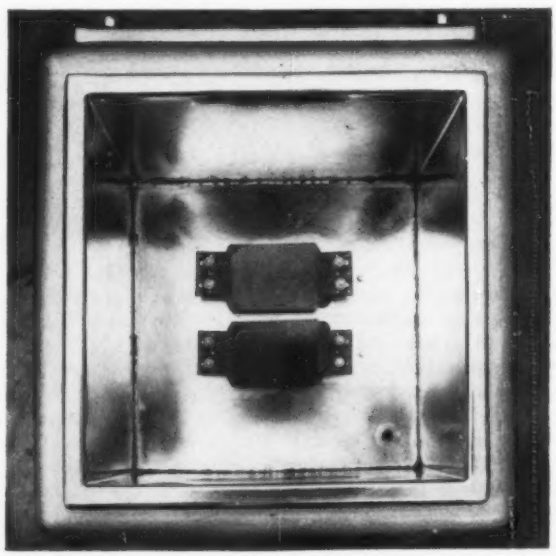


Fig 2. (Left) *An ultrasonic whistle attached to its pump and driving motor. (Photo courtesy Ultrasonics Ltd)*

(Above) *A group of magnetostrictive transducers. Typical materials used are Ferroxcube, Permendur, and nickel. The coils carrying the exciting current can be seen in some of the examples.*

(Below) *Detail of a Kerry-Mullard cleaning tank showing a pair of barium titanate transducers*



particle acceleration in the solvent also plays an important part in the cleaning action.

Cleaning baths of many sizes and types are available, the solvent capacity ranging from a few millilitres to many litres. Small 'pot' cleaners, operating from about 50 W of electrical power, are suitable for use on the assembly bench for cleaning small precision components prior to assembly. Large conveyorized plants, working at several kW of electrical power, are required to match in with modern high production methods. These large cleaners contain other facilities, such as pre-washing and rinsing baths and provision for the continuous filtration and distillation of the solvent. A cleaner of this type is shown in Fig 3. Baths of intermediate capacities are obtainable.

Equipment of a broadly similar type is used for a number of other processes. Two which may be cited are extraction and metal pickling. The pickling of castings and of sheet metal after rolling is normally carried out in an acid bath of fairly high concentration. By the use of ultrasound in the pickling bath, the necessary concentration may be reduced in some cases to as little as one-twentieth of the normal value. In addition to the resultant economy, this is said to reduce the risk of surface damage.

Extraction of essential oils from many natural products, including foodstuffs, may be greatly accelerated by the use of high intensity sound irradiation. The raw materials are treated on a batch basis, being placed in a tank fitted with a number of transducers and containing a liquid which acts as a 'carrier' for the extract. The transducers are normally of the magnetostriction type. Mechanical stirring is provided to ensure uniform irradiation. The quantity of extract obtained from a given weight of raw material is increased significantly and the extraction time is cut to a small part of that normally required.

Emulsification of liquids and the dispersion of pigments may also be carried out by the use of equipment similar to that described above. It is more usual, however, to employ a continuous flow system using a high frequency whistle of the Pohlman pattern fitted directly into a pipe carrying the process liquid. The intense cavitation produced by the ultrasound disrupts the liquid phase and brings about intimate mixing of the components, producing a very fine emulsion or suspension.

There are a number of chemical reactions which may be initiated or accelerated by the use of ultrasound. An example from this group which offers considerable promise is the application of ultrasound to electroplating. Although for the most part only pilot plants are at present in use, the results obtained appear to be quite striking. Increases in the permissible current density of 10 to 15 times have been reported and improvements in plating quality also result. Small plants producing deposits of rhodium and of bright gold are in use.

Manufacturing Techniques

The processes so far described have been directed towards chemical processing or surface finishing. In addition to these, however, a number of techniques have been developed which are of value in the actual fabrication of engineering components.

The current trend towards the use of exceedingly hard materials, particularly ceramics, has brought about the development of ultrasonic machining.[5] By this technique materials may be machined which are resistant to normal methods. A soft metal tool fashioned to match the shape of the required hole is made to vibrate at high frequency with an amplitude of a few thousandths of an inch. This tool, fed with a slurry of water and fine abrasive powder, is brought into contact with the work. As it vibrates the tool drives the abrasive particles into the work, chipping it away in minute fragments. Owing to the many thousands of strokes which occur each second the rate of cutting may be quite high.

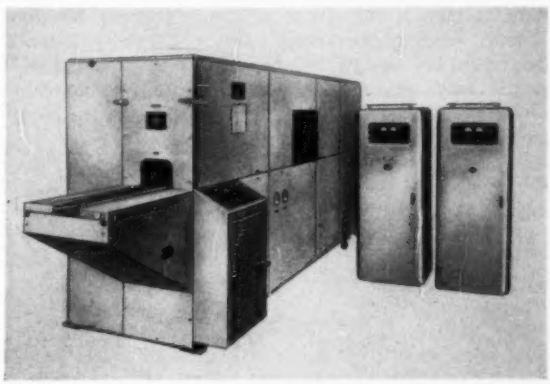


Fig 3. A large Kerry-Mullard conveyorized ultrasonic cleaning plant installed at a factory of AEI–Hotpoint Ltd for cleaning hermetic compressor components

It may be appreciated that, since the cutting tool does not rotate but merely acts as a hammer driving the abrasive particles, there is no limitation upon the shape of the cut which may be made. Indeed, the most valuable applications are the piercing in intractable materials of intricately shaped holes which would require many hours of expensive hand-work by conventional methods.

Ultrasonic drills are available in much the same range of sizes as one would find in conventional spindle drills. A small bench machine such as that shown in Fig 4 is suitable for machining holes up to about $\frac{3}{8}$ inch (9·5 mm) across in glasses, ceramics, and sintered carbides. This machine operates at 20 kc/s from the 60 W generator shown alongside. Larger machines are made working at powers up to 2 kW and capable of making cuts 3 inches (76 mm) across. Such large machines are sometimes fitted with cross slides similar to a milling machine or jig-borer for carrying out accurate tool-making. Another machine, only recently developed and operating upon a different principle, is adapted to tapping and reaming round holes in hard and brittle materials.

In the field of metal joining, ultrasonic soldering and welding offer certain advantages. Most metals may be joined together by the application of sufficient pressure, particularly at high temperatures, but are normally inhibited from doing so by the presence of an oxide layer which forms upon the surface. Ultrasound may be used to break down this layer and permit the bare metal surfaces to come into contact. In the case of soldering,[6] the oxide layer is destroyed by the effect of cavitation in the liquid solder itself. So effective is this method that, for example, aluminium and its alloys, which are normally practically impossible to solder, may be tinned readily. Two types of equipment are used. Small components may be tinned by dipping them into a bath of molten solder which is brought into a state of cavitation by ultrasonic irradiation. An ultrasonic soldering iron, in which the bit of a

conventionally heated iron is vibrated ultrasonically, is suitable for use on components which cannot conveniently be dip-tinned.

Ultrasonic welding[7] is a relatively new development. The two components to be joined are clamped together between the jaws of the machine, only quite moderate pressures being used. One of the jaws is vibrated ultrasonically, thus rupturing the oxide layers separating the two metal surfaces and allowing them to come into intimate contact. A pressure weld is then formed. Normally difficult welding operations may be carried out easily; foils may be welded to thick sections and dissimilar metals may be joined together. Moreover, no major

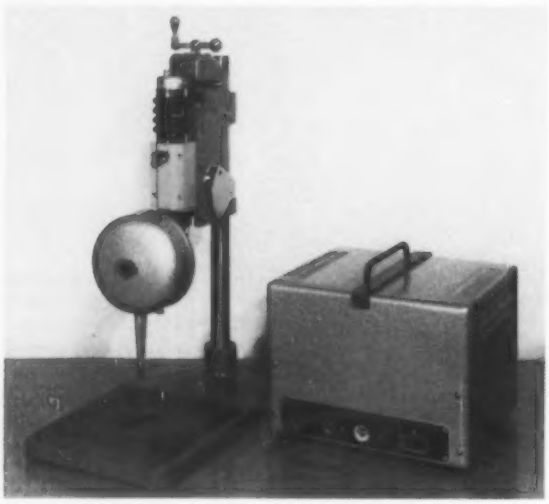


Fig 4. A Mullard 60 W bench-mounted ultrasonic drill

fusing of the work takes place. This technique is yet to find commercial application in this country but should prove valuable when more widely known.

Inspection Applications

No less important than the applications described above are the inspection techniques made possible by the use of ultrasound. One of the most highly developed of these is flaw detection.[8] In cases where the reliability of a component is vital, as is often the case in the aircraft industry, or where expensive machining has to be carried out on a part, it is important to be able to examine the internal structure to ensure the absence of serious flaws. In many instances ultrasonic flaw detection provides an excellent means of accomplishing this.

As mentioned already, high frequency sound beams will behave in very much the same way as light rays. If a crystal transducer is pressed against one face of a component it may be used to propagate a pulse of sound energy into the material of the component. Should this sound pulse encounter a flaw in the material it will be partly or wholly reflected and the echo may be received by the same or another transducer. This is illustrated in Fig 5. The time interval between the transmitted pulse and the return of the echo is a measure of the depth of the flaw. By displaying the two pulses on a cathode-ray tube the depth of the flaw may be indicated visually.

Practically all flaw detectors operate upon this principle, although the number of variations is legion. It is, for example, very usual to use a transducer mounted upon a 'Perspex' coupling wedge; this permits the use of shear waves in preference to compressional waves and so provides better definition. Other transducer heads use shaped crystals for fitting to pipes and other irregular surfaces, double (transmitting and receiving) crystals fitted in one head, shaped coupling wedges for the elimination of certain unwanted components of the sound wave and many other special devices for improving the operation of the instrument.

In order to transmit acoustic energy from the transducer to the material being examined, it is necessary to ensure a good acoustic bond by employing a coupling medium. This is commonly either oil or water and is smeared as a thin film on the face of the transducer.

For large irregularly shaped components it is often difficult to obtain repeatable results owing to the poor acoustic coupling between the probe and the irregular surface. In such cases the whole component may be immersed in a tank of liquid together with the transducer heads. These need then no longer be in contact with the surface of the component and may in fact be several inches away. This method lends itself to semi-automatic examination, the probes being traversed backwards and forwards across the work until the whole volume has been scanned. The operator has then only to watch the screen of the CRT display.

A development which is not yet in general use, by which even this attention may be eliminated, employs a pen recorder which can be arranged so as to draw complete cross sections of the component, marking in any flaws or irregularities. Such equipments, which are being rapidly improved, may well before long give results equal to X-rays without many of the attendant inconveniences.

The frequency at which flaw detection equipment is operated is determined by the minimum size of flaw which it is required to detect. Using a frequency of 5 Mc/s, the

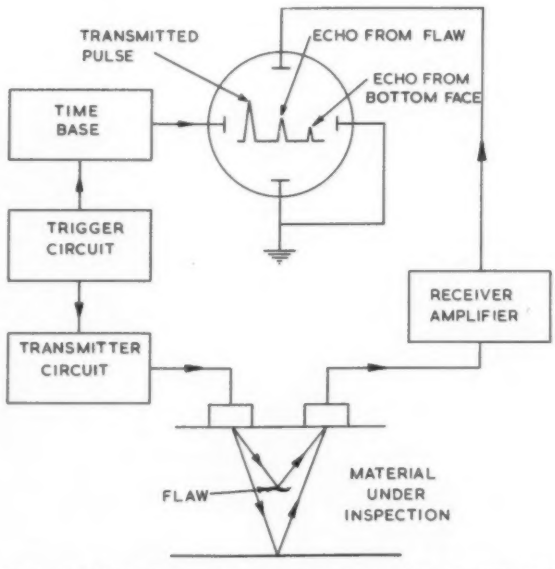


Fig 5. Principle of operation of an ultrasonic flaw detector. The time base of the oscilloscope is triggered by the transmitted pulse; the echo arriving at the receiving transducer is used to produce a deflection of the oscilloscope trace

maximum currently employed, flaws and porosity down to one millimetre in size may be found. Sound of such high frequency, however, will generally be quickly attenuated, and for large objects it may be necessary to use a lower frequency.

Many instances arise where it is required to measure the thickness of plates and other structural members where only one face is conveniently accessible. Clearly a flaw detector of the type already described might be used for this purpose, but specially developed resonance gauges[9] are more accurate. A transducer is coupled to one face of the plate to be measured and driven with a continuous sine wave from a variable frequency oscillator. As the frequency is altered, it will pass through certain values at which the thickness of the plate will become resonant and the apparent impedance of the transducer will change. This may be indicated on a suitable meter. The reciprocal of the resonant frequency may be used as a measure of thickness provided the velocity of sound in the plate being measured is known.

Two refinements of this system are used. In one the oscillator is frequency modulated over a narrow band by an audio frequency. Under resonance conditions this audio frequency will appear as a component of the anode current of the valve driving the transducer. It may then be amplified and fed to headphones. Instead of tuning for resonance manually it is possible to sweep the oscillator frequency automatically throughout the range of the instrument. The resonance can then be displayed on a cathode-ray tube which may be equipped with a graticule calibrated for the material being measured.

The velocity of sound relative to the medium through which it travels is independent of the motion of the medium itself. This principle forms the basis of a method of liquid flow measurement. If sound pulses are launched into the liquid in two opposite directions, both with and against the flow, the two apparent velocities in the two directions will differ. If c is the velocity of sound in the liquid and u is the flow velocity of the liquid itself, then the two apparent velocities will be

$$v_1 = c + u; \quad v_2 = c - u.$$

From this

$$u = \frac{v_1 - v_2}{2}.$$

From this it may be seen that if v_1 and v_2 can be measured, u may be derived. Since v_1 and v_2 normally differ from c by only small amounts, the measurement is usually carried out by a phase comparison method.

In the inspection and measurement techniques discussed so far, the sound wave has been employed as a non-destructive exploratory tool. An application exploiting a quite different principle is ultrasonic fatigue testing.[10] Here the amplitude of vibration of a magnetostrictive transducer is amplified until it is sufficiently great to induce in a metal sample alternating stresses exceeding its fatigue limit. It is thus possible to carry out fatigue tests upon a wide variety of materials.

The value of the alternating stress being applied may be obtained by measuring the vibration amplitude and the elastic constant of the material under test. The number of cycles of stress leading to failure is given by the product of the frequency and the duration of the test in seconds. Since the frequency employed for this method of fatigue testing is usually about 20 kc/s, while conventional testers operate at a maximum frequency of only a hundred or so cycles per second, the saving in time will be immediately apparent. In fact, a test which might by traditional methods take weeks may be carried out in an hour or two.

Conclusion

The literature of the industrial applications of ultrasound is abundant and diverse. Many hundreds of possible applications are described in it; many of them are of great potential value, others are impractical on economic grounds or because the foreseeable demand is not sufficiently great to repay the effort of commercial development. In this review it has been possible to mention only a few of the most important applications in the industrial field, but it is hoped that enough has been included to make clear the advantages made possible by the use of ultrasonic techniques.

When considered on on an industrial scale the cost of installing ultrasonic equipment may in some cases appear to be high—the cost of complete ultrasonic installations may well be in the region of £1 per watt of rated power. While in many instances this may compare favourably with conventional equipment, in others, where simple traditional methods have been employed, the cost may seem to be grossly uneconomic. Often, however, the resultant savings in labour and materials are so great as to offset quickly the initial cost of installation.

It must also be remembered that the efforts of manufacturers are continually being directed towards the development of more economically priced generators and transducers, and it is to be expected that considerable expansion in the use of ultrasonic equipment will take place.

The author wishes to thank the Directors of Mullard Research Laboratories and the Directors of Mullard Equipment Ltd for permission to publish this article. He also wishes to acknowledge the help given by colleagues.

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Britain's Largest Industrial Capacitor Installation

DETAILS have recently been released of this unusually interesting installation, which was successfully commissioned in the early part of last year, only about seven months after the order for the capacitor bank was placed. Here is the story of the reasons for the installation, and descriptions of its many technical features.

At Margam, in South Wales, the Chemical Division of the Distillers Company Ltd has a factory which manufactures calcium carbide. This has been operating since 1940, and the process involves the smelting of lime and coke in three open arc furnaces.

At maximum demand periods, a load of approximately 55 MW at 0·84 power factor lagging is taken from the South Wales Electricity Board system, of which the furnaces constitute the main load.

The Board imposes a financial penalty if the average monthly power factor falls below 0·95 lagging, and in order to avoid this penalty it was decided to improve the average monthly power factor to a value in excess of this figure. To achieve this, British Insulated Callender's Cables Ltd supplied 72 tank-type capacitors which, now that they are installed, form the largest industrial shunt-connected capacitor bank in the British Isles.

Preliminary engineering calculations showed that 18,000 kVAr of capacitors would give the desired improvement. Because the carbide furnaces constitute the major portion of the total electrical load, it was agreed that the capacitor bank should be connected as near as possible to the furnace transformer primary busbars. Also connected to these busbars through 33 kV oil circuit-breakers are two 10 MVA 33/11 kV transformers which supply the auxiliary load of the factory.

Detail of the busbar arrangements. Copper strip busbars connect the bushing terminals of the BICC capacitor tanks to off-load isolating switches, which are connected to the overhead tubular busbar system

It was decided to divide the 18,000 kVAr bank into two equal capacitor sections, one being connected to the secondary side of each 10 MVA transformer, and to use the 33 kV circuit-breakers to switch each section. As an additional precaution, these breakers were up-rated to 750 MVA breaking capacity.

The resultant voltage rise on the secondary side of these transformers was not expected to present any serious problems, and it has in fact been successfully accommodated by adjustment of the off-load tappings on the transformers.

Before the capacitor design was finalized, the harmonic content in the supply wave-form was investigated in conjunction with the South Wales Electricity Board. The results indicated that de-rating of the capacitors was unnecessary.

Details of the Installation

The 10 MVA transformers are connected on the secondary side, through 11 kV oil circuit-breakers, to a ring-main circuit which is provided with a normally open bus-coupler. By closing this bus-coupler it is possible to supply the total auxiliary load from one 10 MVA transformer whenever the other transformer with its associated capacitor bank is switched out of circuit.

Each 9000 kVAr capacitor bank has an oil switch for off-load isolation. This switch has Castell mechanical interlocking with the 33 kV and 11 kV oil circuit-breakers and with the doors of the capacitor building. Electrical interlocking is also provided between the 33 kV and 11 kV oil circuit-breakers controlling the 10 MVA transformers. Facilities are provided for the remote operation of the oil circuit-breakers from panels in a control room which is manned 24 hours a day.

The capacitors could not be installed conveniently in the open, and a building had therefore to be erected to house them. In this building the 9000 kVAr banks were housed in two rooms, each room being completely separate from the other. In each there are thirty-six 250 kVAr 6·35 kV 50 c/s single-phase oil impregnated tank-type capacitors arranged in 3 bays, with an additional bay in case a fourth furnace should be installed.

The supply for the capacitor banks is brought into the building by underground single-core lead-covered cables, terminating in wall-mounting cable sealing boxes in each room. An overhead system of copper tubular busbars supported on porcelain insulators carries the supply to each bay of capacitor banks. Flat copper strip busbars are used for the connexions between the bushing terminals of the capacitor tanks and pole-operated off-load isolating switches, which in turn are connected to the overhead busbar system.

The 12 capacitor tanks in each bay form a 3-phase section of the complete bank with facilities for off-load isolation.

In addition to the normal internal fuse protection of element groups within each capacitor tank, supplementary protection is provided for each 3-phase section of 12 tanks. Each section is divided into two equal star-connected groups with a fully insulated wound primary current transformer connected between the two floating neutral points. A relay in the secondary circuit of the current transformer operates an audible alarm in the control room whenever current flow between the neutral points reaches a pre-selected value. In the event of a serious loss of capacitance in the tank, the alarm will operate before serious over-stressing of the remaining sound capacitors can occur. Indications of bus faults within any section are also ensured.

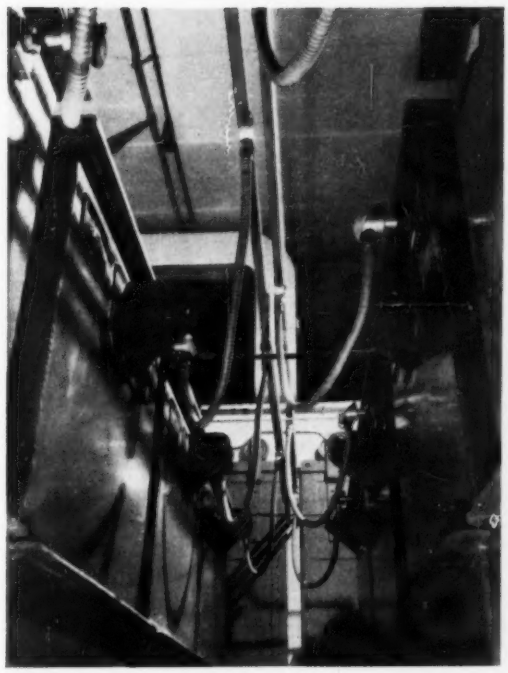
Because of atmospheric conditions it was necessary to pressurize the plant, and in order to keep the temperature within the building to permissible limits, a fairly elaborate ventilating system had to be installed. The total heat loss for the two tanks of capacitors is approximately 45 kW, and the ventilating plant has to dissipate this heat in addition to any heat from the normal outside temperature.

Insulation of the roof has been carried out to limit absorption of heat from outside. At the intake end of the system, filters have been installed and two fans feed air into the ducting. In cold weather, only one fan need be used to keep the temperature below the permissible limit.

The inlet fans and filters are installed in a separate room at the south-west end of the building, with the inlet grille in this wall. The extracter fans are at high level at the north-east end of the building. Visible indication that the fans are running is provided in the control room.

Thermometers installed in the building give remote indication in the control room of ambient temperature in either of the capacitor rooms; should the ambient temperature exceed the permissible limit an audible and visual alarm is provided in the control room. Further, every capacitor tank is fitted with a resistance thermometer connected to a multipoint indicator in the control room.

Although the possibility of an oil fire from any serious failure of a capacitor is remote, carbon dioxide fire-extinguishing equipment has been installed. This system is brought into operation by means of electrical heat detectors located at ceiling level in each room, and audible and visible warnings are given in the control room if the fire-extinguishing equipment operates.



A resistance thermometer is fitted to every BICC capacitor tank and connected to a multipoint indicator in the control room

This capacitor installation will result in an estimated saving to the Distillers Company of approximately £30,000 on their annual electricity bill.

British Insulated Callender's Cables Ltd were responsible for the supply and installation of the capacitors, busbars, cables, and sealing boxes; the English Electric Co Ltd supplied the switchgear and protective gear, and the temperature indicating equipment was by the Cambridge Instrument Co Ltd.

Microfilm Edition of 'The Beama Journal'

BEGINNING with Volume 65, which comprises the February, May, August, and November 1958 issues, THE BEAMA JOURNAL is now available in a microfilm edition.

As a result of arrangements which have been made with University Microfilms Ltd, Dering Yard, 67 New Bond Street, London, W1, THE BEAMA JOURNAL now joins the increasing number of British technical and specialized periodicals which are available on microfilm.

The principle of microfilm libraries has been well established in the USA for many years, and it was in fact a demand from that country for a microfilm edition of THE BEAMA JOURNAL that led to the present arrangements. The trend in the UK, although not as widespread as in the USA, is steadily growing, and well over 100 British periodicals are now listed in the University Microfilms catalogue.

The microfilm edition of THE BEAMA JOURNAL, which is restricted to existing subscribers to the *Journal*, can be obtained from University Microfilms Ltd at the address given in the second paragraph at a price of 16s 6d, or from their American company—University Microfilms, 313, N First Street, Ann Arbor, Michigan, USA, at $2·53.

All orders, and requests for catalogues or further information, should be addressed to University Microfilms and not to THE BEAMA JOURNAL.

Notes

Faraday House Engineering College

The new Board of Governors of Faraday House Engineering College,* of which Colonel B. H. Leeson, the Director of BEAMA, is Chairman, has recently reconsidered the educational policy of the College in view of industry's urgent need for an even greater supply of trained engineers.

It is felt that two major educational objectives are now needed to meet the ever-widening scope of physical and electrical science and engineering, and the increasing trend towards the formation within industry of divisions specializing in a range of products.

The first objective is therefore designed to cover the broadest possible field by similarly broad concepts and study of fundamentals. This is already achieved by the well-known award of the Diploma of Faraday House (DFH), which now has a higher standard than ever before and paves the way to professional status. Two innovations are being made this year.

The first is an intermediate award of 'Graduate of Faraday House' on the successful completion of the academic part of the course. The Diploma is awarded after satisfactory completion of practical training, or in some cases after responsible experience for a longer period. The second is the introduction of an industry-based 'sandwich' course with a series of six months' academic study and six months' practical training.

To meet the second objective, the Board of Governors is introducing a new award in 1959 of 'Associate of Faraday House'. It will be awarded for studies in one of four broad divisions of the field of electrical engineering: power engineering, light engineering, telecommunications, and electronics. The training for the award will be broader than that usually understood as specialist training and is intended to meet the requirements of student engineers who wish to concentrate on one of the above-mentioned divisions after completing the study of fundamentals.

* THE BEAMA JOURNAL, May 1958, p 73.

Advanced Technological Awards

The National Council for Technological Awards has announced a new award for advanced technological research and study beyond the level of a Dip Tech.

It will take the form of Membership of the College of Technologists (MCT), and the National Council intends it to be a 'mark of outstanding distinction granted to a student who has proved his ability by completing a substantial programme of work demanding the application of his knowledge to the solution of a problem of value to industry'.

Although the award will be comparable to a PhD, there is no intention of competing with the Universities. It will be made by a programme of work on research, development, design, production, or market investigation carried out jointly in industry and at college, and close contact will be maintained between the technical colleges and industrial organizations concerned.

Candidates for the new Award will not be restricted to Dip Tech holders.

Golden Jubilee of the Illuminating Engineering Society

In a recent announcement of the details of the programme to celebrate the Golden Jubilee of the Illuminating Engineering Society, Dr W. E. Harper, the Hon Secretary, recalled that fifty years ago the expansion of electric lighting was beginning, and technical contributions were coming from many largely unrelated sources. It was apparent to a few people who were greatly interested in the development that, if expansion were to be really effective, there would have to be means whereby contributors could meet to exchange ideas and propound theories.

Accordingly an informal meeting was convened on February 9, 1909, and it was agreed to form an Illuminating Engineering Society, with the celebrated engineer Professor Silvanus P. Thompson as its first President. By the end of that year the Society had 157 members.

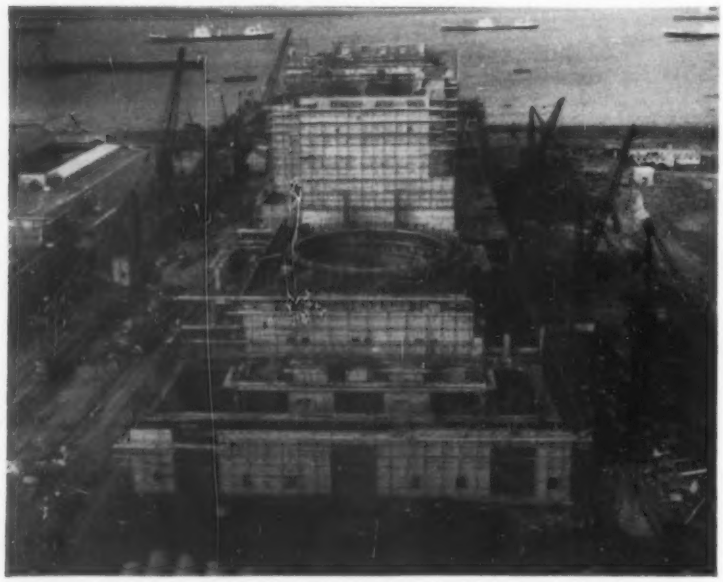
When the Golden Jubilee Commemoration Dinner was held on February 9 of this year at the Criterion Restaurant, Piccadilly, London (where the original meeting was held fifty years ago), those present represented a Society with more than 2500 members and 13 centres in the provinces, plus a centre in South Africa and an overseas membership of more than 300. Among the guests at the dinner were the Lord Mayor of London, the Dean of Westminster, the President of the Royal Academy, and distinguished representatives of science, government, and industry.

Touching on the great achievements of British lighting during the life of the Society, Dr Harper mentioned that the efficiency of modern lamps is 10 times that of the lamps of 1909, and in an age of rising costs it is startling to find that the cost of a 'unit of light' is only about 1/600th of what it was fifty years ago if one takes into account the altered value of money.

The Society issued its first 'Code for Lighting in Buildings' twenty years ago, and the several revisions since then have served to guide not only British practice, but also that of many other countries. The *Transactions* of the Society comprise a body of technical literature on lighting of international standing.

The Jubilee Year Programme is an extensive one, and covers meetings and conferences, lighting displays, lectures and visits in the various centres throughout Great Britain, in addition to more than 130 normal sessional meetings. Lighting displays are also being arranged at electricity service centres, and lectures will be given to many technical and non-technical bodies including chambers of trade, rotary clubs, schools, technical colleges, and so on.

The objective of the Jubilee celebrations is 'to impress on the public, on industry, on civic and municipal authorities and others the Society's belief that lighting is an integral part of the welfare of the community, and to encourage a constantly better use of the resources that are at our command'.



Good progress is being made with the construction of the Bradwell Nuclear Power Station. This photograph, taken by a Nuclear Power Plant Co's staff photographer from the top of the Goliath crane, shows the stage which Nos 1 and 2 reactors had reached in December 1958. In the background is the estuary of the River Blackwater

Field Trials of Buried Distribution Transformers

Over the last twelve months or so, field trials have been carried out in Scotland on a new type of buried distribution transformer made by Ferranti Ltd. The performance of the unit was assessed on both winter and summer loads, and it is stated by the makers that the tests have proved that the unit can successfully withstand the most severe distribution loading conditions.

The transformer is an air-cooled 500 kVA 11000/433 V three-phase unit, utilizing class 'C' materials and fully instrumented. It was developed by Ferranti Ltd after discussions with engineers of the South of Scotland Electricity Board to find a new approach to the problem of system reinforcement.

The ventilating pillar of a Ferranti buried type distribution transformer. This is the only visible part of the installation

The main advantage of the unit is that it can be installed at a load centre without difficulty. Other features are that it requires no plinth, railing, or expensive concealing structure, as it is contained in a strongly protected tank which can be buried directly in the ground.

As class 'C' materials are non-hygroscopic, the danger resulting from damp air being drawn into the tank is eliminated; they are also non-inflammable. Moreover, the use of these insulating materials has brought the size of the core and coils within reasonable limits. Although Class 'C' insulated transformers are inherently expensive in construction, costs compare favourably with those involved in installing a standard conventional transformer in an outdoor substation.

The ventilating pillar which separates the incoming from the outgoing cooling air was designed on the lines of an overground distribution pillar, and as it is offset to one side of the tank, the core and coils can be installed or removed without difficulty. This also has the added advantage that the pillar can be installed in a wall or hedge, while the main tank is buried beneath a pavement, verge, or garden. Thus, the only visible part of the unit can be made to blend unobtrusively into its surroundings.

Careful design has also ensured that the pillar is fully weatherproof, and protection against blockage of the ventilating system by stones or dirt being dropped in, either accidentally or deliberately, is also incorporated. Should the pillar be damaged in a road accident (an unlikely contingency), the operation of the transformer will be unaffected, as the pillar can be safely replaced or repaired without disconnecting the transformer. As no tappings were required, construction of this particular unit was simplified; however, the production of units with tapping links can also be undertaken, access being gained by a man-hole cover as in standard Post Office practice.

Since the transformer was installed, daily readings have been taken on site. These have included: kVA printometer readings; phase current measurement; outlet and inlet air duct temperatures; metal temperature at top of housing; air, soil, and ambient temperatures. All tests carried out on the transformer to date indicate that it will be entirely satisfactory for use in supply networks; that there will be no risk of discomfort or danger to the public; and that it will be relatively maintenance free.

The maximum kVA rating at present in operation is 500, but as operating experience is accumulated, this figure is likely to be increased to around 1500 kVA.

Following the successful field trials, Ferranti Limited have now received a further order from the North of Scotland Hydro-Electric Board.

BTH Research Reports

Some results of recent work by the staff of the BTH Research Laboratory in the semiconductor field are published in the following reports.

'On the Mass-action Laws in Degenerate Semiconductors', by Dr F. W. G. Rose, which defines the effective density of the energy levels in the conduction and valence bands.

'Temperature Dependence of Carrier Lifetime in Silicon', by D. J. Sandiford. The photo-conductivity decay method using an air spark as a radiation source was used to measure the carrier lifetime. Results are given for both p- and n-type silicon specimens together with a discussion of the results.

'An Apparatus for Measuring the Electrical Resistivity of Silicon', by Dr E. L. Heasell, N. R. Howard, and E. W. Timmins. This paper describes an instrument which has been developed for the quick and accurate measurement of the resistivities in the range of 0·02-3000 ohm/cm.

The first two reports are reprinted from the *Proceedings of the Physical Society* and the other from '*BTH Activities*'. Copies of these Reports can be obtained from the British Thomson-Houston Co Ltd, Rugby.

Harwell Reactor School

From time to time courses for senior technical executives in industry are held at the Harwell Reactor School, and the next course on which places are available will be held from June 15 to 25, 1959.

The fee for the course is £52 10s, exclusive of accommodation. Those interested should apply without delay to the address below for application forms and detailed information.

A second course on the Control and Instrumentation of Reactors will be held from July 7 to 17, 1959, inclusive, and will be open to British and overseas students.

The first course held in October 1958 was heavily overbooked. It lasted for five and a half days, but as a result of the experience gained from that course, it was decided to extend the next one to nine days.

The course is primarily intended for those who have a direct interest in the control and instrumentation of nuclear reactors, and it will be assumed that participants have some knowledge of the basic principles of these subjects.

In addition to the lectures there will be visits to zero energy and high flux research reactors and other relevant parts of the Harwell Establishment.

The fee for the course will be £52 10s, exclusive of accommodation. Application forms can be obtained from: The Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire, and must be returned by May 7, 1959.

Applicants will be informed, as soon as possible after this date, if their application has been successful.

Part of the route of the new 275 kV super-grid for the Central Electricity Generating Board crosses a wooded valley in Lancashire with a span of 1600 ft (488 m) between the towers on each side. British Insulated Callender's Construction Co Ltd, who are erecting the line, were asked to exercise special care to avoid damage to the trees, so they used a coastguard rocket apparatus to fire a pilot line across the valley, the pilot line then being used to take over a hauling rope by means of which the conductors were drawn across without damage to the trees

IEE Symposium on Electrical Installations

A SYMPOSIUM on the provision of adequate electrical installations in buildings, arranged by the Utilization Section of The Institution of Electrical Engineers, was held in London recently, under the Chairmanship of Mr R. A. Marryat, Chairman of the Utilization Section.

In his introduction, Mr Marryat said how concerned were members of The Institution to see better and greater use made of electricity; it afforded the most effective means of utilizing coal resources, and electricity distribution was the only channel through which to apply nuclear energy.

He pointed out that the rapid development of new electrical applications, materials, and methods of installation which was continuously taking place made it distinctly possible that where the electrical installations in buildings were only just adequate for present-day needs, they could well become totally inadequate during the time that the building was still being used. Therefore, it was essential to ensure that the provisions now being made for the distribution of electricity in all our buildings were such as to provide, not only for the present, but also for the future needs of better living and higher productivity.

Colonel B. H. Leeson, Director of BEAMA, pointed out in the discussion which followed the papers that the Symposium was the beginning of a campaign for adequate wiring installations, and the purpose of this first stage was for the people connected with the electrical engineering profession and industry, and for architects and builders, to decide what they wanted; at a later stage the campaign would be extended to cover the general public.

The four papers presented confined their recommendations to one of four separate general types of building and gave an outline of the essential provisions that should be made for adequate wiring—adequate referring here not only to quality, but more especially to quantity.

The first paper—'Multi-Storey Flats and Maisonettes'—was divided into two parts. The first dealt with the sociological aspects of the problem and was based on the findings of a special study carried out in London among LCC tenants. The speaker then discussed the various types and systems of electrical installation, with particular reference to subsidized buildings. He gave the criterion of an adequate electrical installation in a dwelling as its ability to cope with the day-to-day demands made by the family when supply is required for lighting, cooking, heating, and motive power.

The next speaker limited his paper to the problems of the private dwelling as opposed to those of block dwellings, dealing in some detail with the adequate wiring of new houses and also the modernization of existing installations. He said that the installation had to be planned to provide the facilities which it was known would be required. Equally important were the anticipation of extensions for future needs and the inclusion in the basic design of the means to facilitate this without undue cost or inconvenience.

Commerical buildings were the topic of the third paper, and the author attempted to equate the seemingly incompatible problems of minimum cost and adequate services in office buildings. The emphasis here was laid on design economy. The paper was extended slightly to incorporate a short consideration of hotels and shops.

The last paper was on small industrial premises. One of the most important aspects from the point of view of the small factory building was the safety factor. All too often it was not appreciated early enough that factories would expand. The consequent additions to electric installations were often unsightly and unsafe; therefore the need for better liaison between architect, consultant, and contractor was very essential.

The lengthy discussion which terminated the Symposium was noteworthy for the able manner in which were expressed the views of a wide variety of interested bodies including architects, builders, and housing authorities. Mr E. J. Davies, who was the official representative of BEAMA at the Symposium, pointed out that manufacturers of domestic appliances were meeting all the demands for modern labour-saving devices, but the effective use of these appliances must not be made difficult by failure to provide enough socket-outlets.

Transistor Convention and Exhibition

THE Institution of Electrical Engineers is arranging an exhibition, to be held at Earl's Court, London, from May 21 to 27, 1959, in conjunction with the International Convention on Transistors and Associated Semi-conductor Devices.

The IEE has stated that at least 2000 delegates are expected to attend the Convention from all the major industrial countries of the world, including the USA and USSR, and has emphasized that the Exhibition is closely linked to the Convention. It has been planned to appeal only to those with a technical interest and its primary purpose is to provide adequate facilities for exhibits and demonstrations associated with the subjects of the Convention. The total area available for exhibition purposes is about 25,000 square feet (2323 sq m), of which about one-fifth is being allocated to exhibitors from overseas.

Responsibility for the Convention is in the hands of the Radio and Telecommunications Section of the IEE. The Exhibition is being organized by Industrial and Trade Fairs Ltd, Drury House, Russell Street, London, WC2, on behalf of The Institution of Electrical Engineers.

New Specialist Factory for Gear Production

THE old-established firm of W. H. Allen Sons & Co Ltd have recently modernized their Atlas Works at Pershore, Worcestershire, and re-equipped them as a highly specialized plant for the production of the company's epicyclic and parallel-shaft gears, with production facilities that have been progressively expanded and developed in line with the great advances in gear-cutting technique.

The firm of W. H. Allen Sons & Co Ltd have built up over their seventy-seven years of successful progress and expansion a world-wide connexion for a range of products which includes steam and gas turbines, steam and diesel engines, condensing plant, pumps, fans, electric generators, motors, control gear and switchboards, and the gears which form the subject of this story.

Design, manufacture, assembly, and testing of all these products have been carried on at Queens Engineering Works, Bedford, with two subsidiary factories at Biddenham Works, Bedford, and Atlas Works, Pershore. It was found, however, that even after enlarging and re-equipping Queens Engineering Works soon after the end of World War II, the capacity was inadequate to cope with the expanding demand for Allen gears, and the problem became still more acute when the company started to manufacture epicyclic gearing in addition to the parallel-shaft reduction gearing which was made in considerable numbers for use with Allen steam-turbine generating sets for land and marine applications.

Art and Precision in Gear-Cutting

It was therefore decided that Atlas Works should be modernized and re-equipped with some of the most up-to-date precision machinery in the world for the production of gearing. Some of the special gear-cutting machines were transferred from Bedford and supported by many new general-purpose machine tools. It is perhaps significant that, even with the most modern equipment available operated under carefully controlled conditions, gear-cutting remains to a large extent an art in which long experience makes a substantial contribution to the success of the results.

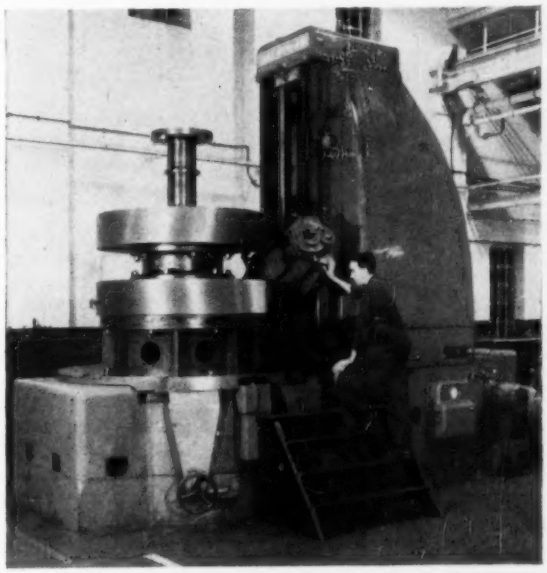
The large main machine shop is used for general-purpose machining, with the heavy machines concentrated under the main overhead crane running along the centre of the shop, and the lighter machine tools in the side aisles where the roof is lower. The gear parts produced on these machines are handled by electric hoists.

Towards one end of the main shop are the large horizontal borers and the 100 inch (254 cm) Lumsden surface grinder used to surface the joint faces of all the gear cases. This machine obviates the need for planing and subsequent filing and scraping; it removes metal at a high rate and produces extreme accuracy with a high surface finish.

The other general-purpose machine tools include centre-lathes, capstans, milling machines, internal and external grinding machines, and precision boring machines. Two electromagnetic Avery dynamic balancing machines are installed, each capable of balancing components weighing up to 6000 lb (2721 kg). An electric annealing furnace is installed at the end of the shop for stress relieving the components between machining operations; it can handle parts up to 4 ft cube (122 cm), and the temperature and time cycle are automatically controlled.

Most of the machines in the gear-cutting shop were transferred from Bedford. They include high-precision gear-hobbing machines, gear shapers, gear grinders, shaving machines, and a specialized jig-boring machine used as a production machine for precise positioning of the holes for the planet wheel spindles in the planet carriers of epicyclic gears, and for boring and milling other high precision components.

The largest gear-hobbing machine is a 72 inch (183 cm) David Brown-Muir machine capable of producing gears to Grade A accuracy. It has been found that even closer temperature control is desirable for this machine than that which can be achieved with the general shop system, and a special enclosure is therefore being built for it. The smaller machines do not call for such fine temperature control, as their machining times are relatively short.

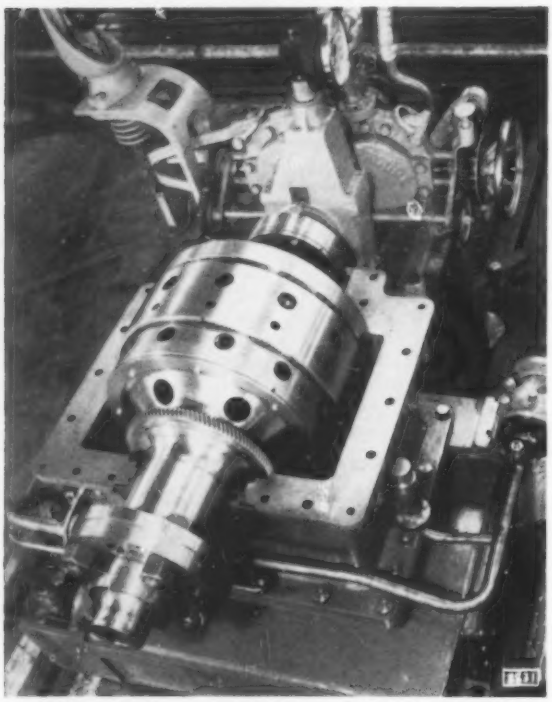


The 72 in (183 cm) David Brown-Muir gear-hobbing machine in the gear-cutting shop

The two shaping machines in this shop were specially built to the company's own specifications to obtain the extreme degree of accuracy required. They are used for producing epicyclic gear sun and planet wheels in which both helices can be cut simultaneously, and for the production of internal gear rings.

Inspection and testing routines are meticulous. Crack detection is carried out on all materials and components which have been hardened; all gear tooth components are inspected and checked on special equipment which includes two measuring machines and a No 2 and No 4 Goulder gear checker. A notable feature of the organiza-

tion is that a complete inspection record is kept of all the gear tooth components manufactured. This begins with a certificate which gives the composition and hardness of the material used, and then includes details of all the checks of tooth profile, helix angle, pitch-to-pitch accuracy, and final hardness after hardening.



Epicyclic speed-increasing gear for 2400 hp motor-driven boiler feed pump. This picture shows the gear assembled for testing

The test bay includes a Ward-Leonard control system in conjunction with dc motors to provide variable-speed running conditions, and a small high-speed water-brake for light load tests.

The hardened components used in the epicyclic gears are usually nitrided, and it is a feature of the production system that most of them are shaved before nitriding, with no further operations on the profiles of the teeth. Some components, however, which are carburized and hardened, are subsequently ground.

In the same shop are facilities for white metal lining and facing all bearings and planet wheel spindles. It is unusual for white metal to be applied to the outside of a spindle, but the company have found that this treatment offers technical advantages, and they consider it essential that the bearings of planet wheels should be formed in this way. They have accordingly developed special techniques for this purpose. Honing the bores of the wheels which run on the spindles is the only post-nitriding operation which is carried out.

Epicyclic gearing has been increasingly adopted in recent years for transmitting a very wide range of powers at varying speed ratios, and a majority of the gear units produced by the firm are now of epicyclic design. In particular, there has been a rapid growth in the use of the highly developed double-helical gear in place of the earlier spur or single-helical design, and the following figures supplied by the firm are significant. In 1951, the applications were few and the total horse-power small. Between then and the early part of 1958, the number of applications in Europe alone had risen to 1500, transmitting a total of 3,000,000 hp. This shows an average of 2000 hp for each gear, but in fact the actual horse-powers vary from about 100 to over 10,000. The input speeds also cover a wide range varying from a few revolutions a minute up to 45,000 rpm.

The main advantages of epicyclic gears are the considerable savings in weight and space as compared with parallel-shaft gears, by reason of the fact that the transmitted load is shared between several tooth contacts. Load sharing is achieved by the provision of an annulus system which is in itself flexible and which is connected to the gear case or shaft by a double gear tooth type flexible coupling. In addition, in high-speed applications the central sun wheel, which is supported by the planet wheels and has no bearings, is connected to the high-speed shaft by a double tooth type coupling.

Some Representative Applications

A 160 hp two-speed epicyclic gear was supplied for a new type of mine tunnelling machine. It transmits a maximum output torque of 110,000 ft-lb at a minimum speed of only 9 rpm, and is driven by a two-speed motor at either 1500 or 650 rpm. Thus four output speeds are available: 24 or 18, and 12 or 9 rpm. The gear unit has an overall ratio of just over 80 : 1, and this large reduction and high torque are obtained from a unit only 6 feet (183 cm) long and weighing only 5·5 tons. The diameter of the largest annulus is 30 inches (76 cm). Four similar units are also to be used on mine tunnelling machines.

Another gear, for use with a motor-driven feed pump, is a speed-increasing gear designed for transmitting 2400 hp from a motor speed of 1500 rpm to a pump speed of 4500 rpm. This gear is interesting in that it has no main bearings. The rotating annulus assembly forming the low-speed shaft is connected directly to the motor shaft, and the high speed sun wheel is supported between the three planet wheels and coupled directly to the pump shaft through a gear tooth type flexible coupling. This arrangement eliminates the use of external flexible couplings and offers a very compact gear unit.

Gears of similar design are being manufactured for compressor and blower drives, including one for an 11,000 hp motor-driven centrifugal compressor installation in Canada.

Other interesting developments include a 3500 hp reverse/reduction gear for marine propulsion, designed to transmit full power ahead or astern. No clutches are used, and reversing is achieved by a hydraulically operated brake. The complete gear box is of special design, incorporating a hardened and ground vee-drive and parallel shaft transfer gear in addition to the epicyclic reversing reduction unit. A number of these units are being built for the Admiralty.

Two large epicyclic gears have been in service for the past two years on mine shaft duty at one of the National Coal Board's collieries, and a third is being built for the same purpose. They will eventually be tower-mounted for mine hoisting, and are capable of transmitting 3200 hp continuously if required from the motor speed of 486 rpm down to the winding drum speed of 64 rpm. The annulus diameter is 43 inches (109 cm) and the complete gear weighs only 9 tons.

New equipment and processes

New Range of Switch-socket Outlets

Standardization is the main feature of a comprehensive new range of round pin 2, 5, and 15 A switch-socket outlets marketed by *MK Electric Ltd*. Both surface and flush units make use of standard components and are built to uniform dimensions; this, say the makers, has enabled them to reduce production costs substantially, and the new designs are therefore offered at very competitive prices.

All the flush designs have $2\frac{3}{8}$ inches (60 mm) fixing centres and are suitable for the square BS box. This applies to units with and without pilot lamps, and as they are interchangeable with existing unswitched socket outlets of the same ratings, considerable flexibility is possible. The small overall size gives a neat, compact appearance and the position of the terminals makes for easy wiring.

The range includes 2, 5, and 15 A ratings, either surface or flush patterns, all available with or without pilot lamps. Surface units have steel cover plates finished in aluminium stove enamel, or brass plates finished in antique bronze, or matt chrome. Flush patterns have insulated plates in brown or ivory, or brass plates finished as above.

Hotpoint 'Hi-Speed' Kettle

New technical features have been incorporated in the 3 pt (1·7 l) 2 kW 'Hi-Speed' kettle recently introduced by *AEI–Hotpoint Ltd*.

The 2 kW 'Torribar' sheathed wire element is claimed to bring one pint (0·57 l) of water from 62 deg F (16·7 deg C) to boiling point in 2 min 8 secs, with a relative gain in speed for larger quantities up to the kettle's total capacity of 3 pts (1·7 l), which can be brought to boiling point in 5 mins 20 secs.

The element heating spiral is made from 80/20 nickel chrome wire embedded in specially graded fused magnesium oxide and encased in a copper tube which is nickel and chrome plated. The construction provides a high electrical loading with a small thermal mass, giving maximum efficiency with rapid heat transfer. The element is shaped for easy insertion through the lid opening, and when in position it has sufficient clearance to prevent sealing over in hard water areas, but is low enough for small quantities of water down to 0·9 pt (0·51 l) to be boiled.

The safety device presents some novel features. It is robust, automatic, and self-resetting, and does not depend on the ejection of a live connector. It is designed to protect the element from overheating if the kettle is allowed to boil dry or is switched on when it is empty, and its action is to make and break the element circuit in a time cycle which reduces the input watts to an average value of about 4 per cent of normal, at which load the dry element is stated to function indefinitely without even affecting the plated finish.

The device, which is built into the element head, makes use of a bi-metal strip which causes two silver contacts to separate when an excessive temperature rise occurs. The 'break' action is rapid, but the automatic 're-make' action is so slow that the element has time to cool.

The lid of the kettle is adequately vented for the escape of steam; the short spout is designed to pour easily, and neither to drip nor allow water to be ejected when the kettle is boiling. The moulded handle, in red or black, is shock-proof and heat insulating. The body is chromium plated externally; nickel plated internally.

The kettle is available with a loading of 2, 1·5, or 1 kW in voltage ranges of 200/220 and 230/250, but the 2 and 1·5 kW loadings are also available for export in the 220/230 V range. It can also be supplied for the 110/120 V range.

Easily Installed Wiring Trunking

Crompton Parkinson Ltd have recently introduced 'Power Line' trunking, which enables moderately rated power circuits and communication networks to be installed alongside existing lighting wiring, but with each of the three systems in completely separate wiring runs.

The new trunking is primarily designed to be attached to one or both sides of Crompton Parkinson's 'New Line' lighting trunking, but it may also be attached to walls or benches as an independent installation. Wherever sited, the cables are simply placed into the trunking with no 'drawing-in', making this one of the easiest methods of bringing electrical power and/or communication networks to the bench or machine tool.

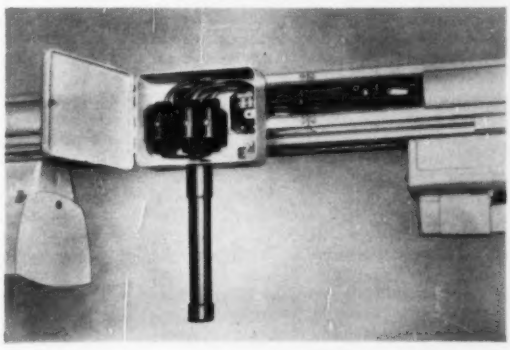
'Power Line' trunking, which is in the form of a channel, is manufactured in 15, 9, and 6 ft (457, 274, and 183 cm) lengths from 16 gauge (1·626 mm) rolled steel, with a galvanized finish to give reasonable protection from moisture or damp atmospheres. Simplicity of installation is one of its main features, and only a screwdriver is required for the actual erection. Clamping plates, riveted to the channelling during manufacture, are spaced at intervals of 3 ft 6 in (107 cm), and tightening the screws in those plates interlocks, secures, and makes earth continuity contact with the supporting lighting trunking.

Cable supports, pressed out from the clamping plates, protrude into the channelling and are fitted with plastic sleeves to protect the cables. As many as eight 19/0·064 in (19/1·626 mm) TB and C or PVC cables can be accommodated on the cable supports. Robust line taps for tap-off conductors up to 7/0·036 in (7/0·914 mm) are available.

Pressed steel three-phase and neutral fused boxes, finished in grey stoved enamel and incorporating Reyrolle 'Pullcap' fuse units complete with HRC cartridge fuses rated at 5, 10, 15, 20, and 30 A are available and can be easily fitted to any point on the trunking. Holes of 1 in (2·54 cm) diameter are provided in the bottoms of the terminal boxes for connecting flexible or rigid tube conduit down leads. Steel-wire armoured cables may also be introduced into the terminal box through suitable glands.

Earth bonding plates are supplied for use between lengths of trunking, and snap-on plastic covers prevent the entry of dust and dirt. Heavy gauge cadmium-plated steel end-plates are supplied for the extremities of runs.

The adaptability of the system enables alterations and additions to be incorporated merely by removing the plastic-covering strip, inserting the necessary line taps, attaching a terminal box and then replacing the covering strip. Existing boxes may be moved to new positions, leaving the original line taps in position to ensure continuing insulation of the cables.



The interior of a fused box on the Crompton Parkinson 'Power Line' trunking, showing the three fuse-holders and the neutral terminals. Where the snap-on cover has been removed the line taps and cables are visible. The four screws to the right of the fused box retain the earth bonding plates between sections of the trunking

Improvements to GEC 'Superspeed' Kettles

The General Electric Co Ltd recently announced that they have developed improved manufacturing techniques for their 'Superspeed' kettle elements.

The element tube has been reduced in size and formed into a D section near the centre, so providing greater contact area with the element heads and very rapid heat transfer to the cut-out mechanism. The modified shape also gives a lower cross-section, and the total element weight has been reduced by more than 20 per cent.

It is stated that, as a result of these improvements, the cut-out mechanism operates under 'boil dry' conditions with less of the element tube exposed above water level, giving even longer life to the element as well as enabling the most economical amount of water to be boiled.

Welding Generator for use with Land Rover

The Land Rover, first introduced some ten years ago, struck a new note in petrol-driven

vehicle design, and it was soon apparent that it could readily be adapted to drive a small welding generator. Accordingly, the *Lincoln Electric Co Ltd* modified their SA 105 A generator unit, which had been supplied for many years as an electric motor-driven set, and equipped it with a belt drive to run from the centre power take-off of the Land Rover transmission. This combination has proved a valuable mobile source of welding current for use on the farm, in the quarry, out on construction jobs, or in the ship repair yard.

With the recent introduction of the new Series II diesel-engined Land Rover, the Lincoln Electric Co Ltd is now able to supply a complete 'packaged' welding machine with a current of 30-200 A which can be mounted on any Land Rover fitted with a rear power take-off simply by removing the tail-board, and with no modification to the Land Rover itself except for the provision of an engine speed governor on petrol engined vehicles.

The LR 150 'Package' welding unit, complete with mounting frame and a comprehensive set of accessories to enable welding to be done immediately, can be delivered *ex* stock. Full details can be obtained from Lincoln Electric Co Ltd, Sales Dept, Welwyn Garden City, Herts.

The Lincoln LR 150 portable welding generator mounted on a Land Rover. (The pulley cover has been removed to show the belt drive)

Warning System for Overhead Cranes

Stated to be the first equipment of its kind to be installed in a European steelworks, a new crane approach warning system has recently been developed by the *British Thomson-Houston Co Ltd* and extensively tested in one of the iron and steel works of Richard Thomas and Baldwins Ltd.

The problem was to eliminate the ever-present danger of collision when two or more overhead travelling cranes are operating on the same track, since the crane driver must concentrate on his load and the signals of his slinger rather than on the movement of neighbouring cranes.

The solution as evolved by BTH is based fundamentally on the principles of the echo sounder. An oscillator circuit generates short electrical pulses at regular intervals which are emitted in the form of high frequency sound by a loudspeaker fitted on the crane. These pulses are reflected by a special trihedral reflector fitted on the neighbouring crane and the echo is picked up by a microphone mounted alongside the sound source. The microphone signal is amplified and fed to relays which may operate an audible alarm or visual indicating circuits in the driver's cab, or they may be used to initiate automatic braking of the crane.

An important feature of the equipment is that the protection system can be made to operate at any desired position on the crane track merely by placing a trihedral reflector in the path of the sonic beam. Overrunning at end stops can thus be avoided and—even more important—complete protection can be given to maintenance men working on a disabled crane or on the crane track, as the reflectors weigh very little and can easily be mounted in the path of the working cranes.

The range of the equipment at present is up to 60 ft (18 m) from the reflector. The oscillating frequency is 11 kc/s, and the time taken for a return echo to operate the protective system is 2 milliseconds per foot. Selective circuits are designed to make the alarm system unresponsive to any signals other than those of the genuine echo.

The equipment is designed to operate from any dc crane supply, but where cranes operate on ac, suitable rectifiers may be supplied for conversion.

The installation has, it is stated, proved eminently successful in service, and it has withstood arduous conditions of heat, vibration, and dust without breakdown or reduction in efficiency. It has solved a problem which has been troubling the steel industry for many years, and is an invaluable contribution to industrial safety.

An Electrical Timer-Counter Unit

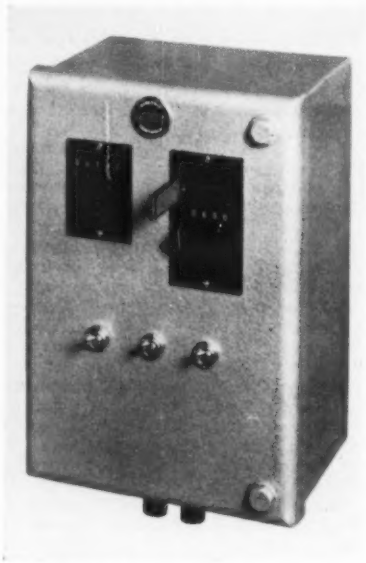
Lindars Automation Ltd, a subsidiary of Dunford & Elliott (Sheffield) Ltd, have recently developed a small and compact combined 'events per unit time' and 'time per unit event' counter.

Basically the unit consists of an electrical pre-set counter, an electrical resetting counter, and a 1 revolution per second synchronous motor giving 10 impulses per revolution. The required time may be set on the presetting counter up to a maximum of 999·9 seconds, and when this has expired, the number of events will be displayed on the resetting counter. Alternatively, should it be required to time a number of events then the number may be pre-set; when these have been completed, the elapsed time is displayed to a 1/10th of a second.

It is necessary for the events to be in the form of impulses received from, say, a micro-switch, photo-cell, etc., and they may be up to a maximum of 10 per second. To ensure accuracy, first pulse suppression is incorporated, the first pulse starting the timing but not registering on the counter.

Advantages of this unit over the more conventional stop-watch method are that the count remains on display, and as no reading 'on the fly' is necessary, human error is eliminated.

Possible uses for this unit include accurate measurement of shaft speed, process timer checking, rate of package flow, vehicle rate check, and similar operations.



The electrical timer-counter unit made by Lindars Automation Ltd

Developments in Ceramic-to-Metal Seals

A considerable amount of work has been carried out on the technique of ceramic-to-metal sealing by *Ferranti Ltd*, who initiated in 1955 a research programme to investigate the possibilities of using ceramic-to-metal seals to replace the more conventional glass-to-metal seals and to overcome some of the latter's limitations.

One result of their work is that Ferranti ceramic-to-metal seals are now widely used in the atomic energy and the chemical industries as terminals for vacuum and pressure vessels operating at elevated and subnormal temperatures.

This development arose from the requirements of the atomic energy industry for a considerable increase in the standard of reliability of the seals used as terminals in equipment such as atomic particle detectors, etc. Ceramic-to-metal seals were found to provide a solution to this problem, particularly as alumina ceramic has a low neutron cross-capture section and the materials used in the seals are for the most part compatible with liquid alkali metals, magnesium alloys, graphite, and so on. Moreover, alumina metal ceramics are ideally suited to vacuum and pressure vessel applications on the grounds of mechanical strength, low thermal shock, and high melting point.

Other advantages arise from the fact that ceramic components can conveniently be ground to close tolerances, and from the nature of the sealing techniques. It has been found, for example, that above about 140 deg C for lead glass and 200 deg C for borosilicate glass, a dc voltage across a seal gives rise to electrolysis, altering the structure of the glass and giving an expansion mismatch leading to leakage and fracture.

This phenomenon has not yet been observed in ceramic-to-metal seals.

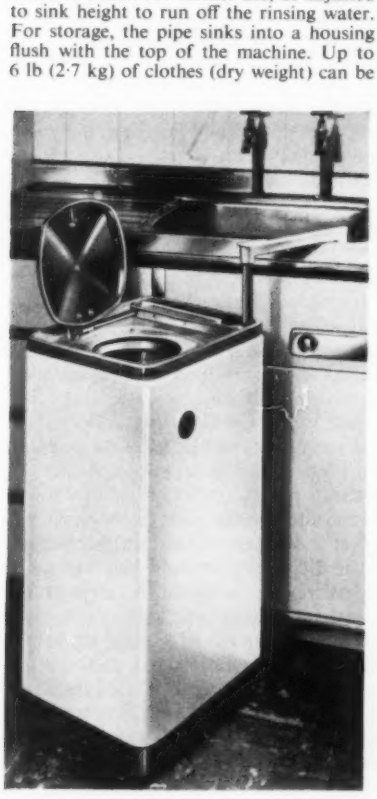
A wide variety of disc, compression, and butt type seals is now available for such diverse applications as valve envelopes, terminations for single and multicore cables, and as thermo-couple seals for furnaces. Ferranti Ltd are now manufacturing seals from 1 inch (25·4 mm) up to 4 inches (102 mm) in diameter (the largest size is now under development), and they can be supplied ready for assembly into equipment by argon arc welding, ECH brazing, or torch brazing.

Recent investigations have shown that it is possible to make vacuum tight seals to pure alumina at a brazing temperature of 1250 deg C, which should meet the valve engineers' requirements for the highest possible bake-out temperature coupled with inert pure oxide ceramic material.

The Hoover 'Spinarinse'

Following the Hoovermatic combined washing machine and spin dryer, *Hoover Ltd* introduced towards the end of last year a separate spin dryer known as the 'Spinarinse'. It is stated to be the only appliance of its kind with an automatic pump for emptying, so avoiding the use of pails and gravity emptying.

The pump ejects through a rigid plastic water outlet pipe which can be swivelled to deliver the hot suds to a washing machine or other container for further use, or adjusted to sink height to run off the rinsing water. For storage, the pipe sinks into a housing flush with the top of the machine. Up to 6 lb (2·7 kg) of clothes (dry weight) can be rinsed and spun without being removed from the machine.



The Hoover 'Spinarinse' spin dryer with outlet pipe adjusted to eject into a sink

The 'Spinarinse', which is stated to have one of the highest water extraction efficiency rates, is powered by a 350 W motor and has a minimum speed of 2300 rpm. A flexible rubber diaphragm at the base of the outer casing centralizes the rotating spin basket and takes up excessive vibration when the clothes are out of balance. Control is by opening and shutting the lid, and an automatic brake stops the spinner within 5 seconds of opening the lid. The machine is stable in operation and easy to move on its four rubber wheels.

It is finished in white, blue, and grey. Dimensions are 30½ in (77 cm) high, 13½ in (34 cm) wide, and 15¾ in (40 cm) from front to back. Weight is 48 lb (26 kg). The motor is fully suppressed against radio and television interference. The machine casing is earthed and the electrical equipment is doubly insulated. It is available in all normal ac voltage ranges.

Precision Pulse Generator

Designed primarily for accurate measurement of pulse height analyzer channel threshold and width, a new precision pulse generator marketed by *Sunvic Controls Ltd* should also find many other applications in which a shaped pulse of stable and accurately known amplitude is required.

The instrument consists of three main sections: stabilized power supply, voltage divider network, and pulse-forming network. Pulse amplitude is adjustable over the range 0 to 40 V by the main control, and there is also an incremental control which provides continuous variation over a range of 0 to 1·2 V with a linear accuracy of ±2 mV.

The overall amplitude stability during an eight-hour period is stated to be better than ±0·05 per cent (allowing for a mains variation of ±5 per cent).

A three-position switch selects pulse widths of 1, 5, or 25 microseconds. Pulse polarity may be either positive or negative at a repetition rate equal to the mains frequency.

Dimensions of the instrument are approximately 11 in high by 19 in wide by 10 in deep (28 cm by 46 cm by 25 cm) and its weight is 30 lb (13·6 kg).

A Compact Insulation and Continuity Tester

Under the trade name 'Metrohm', a new insulation and continuity tester has been introduced by *Everett, Edgcumbe & Co Ltd*. Weighing only 2½ lb (1·13 kg) and measuring 7¼ by 4⅝ by 3 in (184 by 143 by 76 mm), it can be held and operated in one hand; yet within its small compass it provides facilities for insulation, resistance, and continuity tests.

Technically, it represents an important advance by using a transistor-operated voltage convertor for the insulation resistance range; the power source is a 9 V battery pack, and the output voltage is either 500, 250, or 100 V dc, depending on the model required. The output voltage is stated to be exceedingly stable, and other advantages claimed are: high conversion efficiency, low current drain on the battery, greatly reduced ripple content, and improved regulation over the working range. For continuity tests, the battery is used as a direct source.

The 'Metrohm' insulation and continuity tester

Operation is by a single press button, and no current is drawn from the battery except when testing. Provision is made for adjusting the calibration as the battery voltage falls after long use. A 3-position selector switch provides for (1) checking the insulation test voltage, (2) insulation testing on the MΩ scale, (3) continuity testing (checking voltage and testing) on the Ω scale.

Ranges available are: 0·15 to 50 MΩ on the 500 V model; 0·1 to 25 MΩ on the 250 V model, and 0·3 to 10 MΩ on the 100 V model. Continuity range on all models is 0 to 50 Ω.

The instrument is supplied with leather carrying-strap, detachable polythene cover, and 5 ft (152 cm) test leads; longer leads can be supplied to special order.

Trade Publications

Isomantles. A comprehensive catalogue describing electric surface heating mantles and their applications. *Isopad Ltd*, Barnet By-Pass, Boreham Wood, Herts.

Turbine driven feed pumps. Two leaflets describing 'SD' and 'QB' series of feed pumps manufactured by *G. & J. Weir Ltd*, Cathcart, Glasgow, S4.

Autopak automatic arc welding equipment is described in detail in a twenty-page publication issued by *Rockweld Ltd*, Commerce Way, Croydon, Surrey.

Control equipment for pumping and sewage drives is described in detail in Leaflet No 1114 issued by *Brookhirst Switchgear Ltd*, Northgate Works, Newry Park, Chester.

Electric hammer drills are described in a leaflet entitled 'Is this your Problem?' published by *Victor Products (Wallsend) Ltd*, Wallsend-on-Tyne.

The First 25 kV Electric Locomotive

THE vast electrification scheme of British Railways is forging steadily ahead, but the extent and range of the work involved is so enormous that for some time to come progress must necessarily be steady rather than spectacular.

Nevertheless, events occur from time to time which can justly be regarded as high-lights in the developing story of electrification, and one of them took place towards the end of last year, when Britain's first 25 kV ac electric locomotive made its first run with a passenger train over the first portion of the London Midland Region main line to be completely electrified—a 9½ mile (15·3 km) stretch between Crewe and Manchester.

On this occasion, the passengers were members of the press and railway technical staff, and the locomotive—No E 1000—will normally be used only for the training of drivers and the testing of equipment pending completion of the electrification of the whole 31 miles (50 km) between Crewe and Manchester and the delivery of the electric locomotives now on order.

The first 25 kV electric locomotive to go into service on British Railways

By 1960, electric services on this part of the line will be in full operation; by 1963 they will have been extended to Birmingham and Liverpool, and by 1968 there will be through electric services between London, Birmingham, Manchester, and Liverpool.

By any standards, the electrification of this part of the British Railways system is a gigantic task, and it is the more noteworthy because, in effect, the London Midland Region is building a new railway while existing services are still running.

A measure of the extent of the work can be gained by what is involved even on the 31 miles (50 km) of track between Manchester and Crewe. Some 88 bridges have had to be reconstructed, tunnels opened out, a new signalling system installed, stations rebuilt, and platforms lengthened.

The bridge reconstruction programme has been necessary because the new electric services will need greater height clearance for the overhead wiring. The engineers have adopted a unique method—they have built new bridges over the old ones and blown away the former structures with explosives. Not all the bridges, however, have been dealt with in this way. In some cases it has been possible to increase the clearance by lowering the tracks—which has meant digging out hundreds of tons of clay with mechanical excavators.

The opening of one series of tunnels presented a big problem, as they have above them an important road intersection. It was decided to remove the top of the tunnels altogether, thus creating a railway cutting across which two road-bridges (one carrying a roundabout) and one footbridge would have to be constructed. The roundabout requires the construction of a bridge 170 ft (52 m) between the parapets, this work and the removal of the old tunnel being carried out in such a way as to cause the minimum obstruction to rail traffic and taking about ten months to complete.

The signalling installations have had to be remodelled to cater for the faster and more frequent electrified services. The first major re-signalling change-over has already been carried out on the Wilmslow–Slade Lane Junction stretch of line, and all the lines between Crewe and Manchester will be similarly treated.

Colour light signalling and continuous track circuiting will be provided on all running lines, with automatic and semi-automatic control instead of manual block working. Concurrently with the installation of colour light signalling, British Railways standard automatic train control ground equipment will be provided. The signalling and telecommunications equipments are designed so as to be suitable for use with the 25 kV ac traction system.

Specially Screened Cables

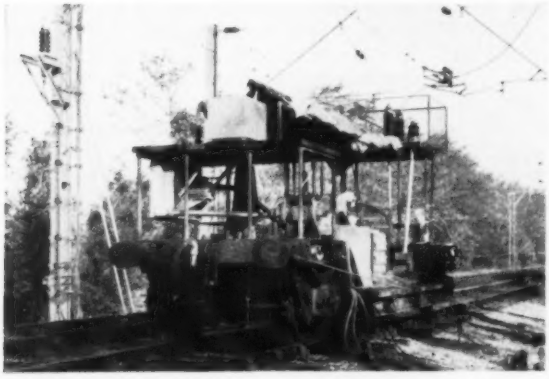
Existing open wire pole routes between Crewe and Manchester will be replaced by specially screened aluminium sheathed steel tape armoured cables. The comprehensive cabling scheme, as planned, provides for the new telecommunications system and caters for increased demands for communications facilities arising from electrification and re-signalling. Provision is also being made in the new cables for traction supervisory pilot circuits and electrification telephone circuits to link Crewe electric control room with feeder stations, track section cabins, and lineside electric traction switching points.

The first section of the line already completely electrified has been used as a pilot scheme. As 25 kV single phase ac electrification is new in Britain, provision has had to be made for the testing of new techniques and equipment. Three types of overhead equipment have been installed on this section of line for the purpose of testing each type under actual running conditions, and work such as this will be of great value in the completion of the remainder of the major electrification schemes.

This line is also being used for training the 206 instructors and motormen and the 88 guards required to operate the Crewe to Manchester service, and this, as mentioned earlier, is the primary role of locomotive No E 1000.

This locomotive has an interesting history. It was originally built by the Metropolitan-Vickers Electrical Co Ltd as a gas turbine locomotive, and ran experimentally on the Western Region. It has now been converted by its makers, on the order of British Railways, as the first traction unit for the new 25 kV ac system, pending the completion of the 100 new Bo-Bo locomotives which Metropolitan-Vickers are now building for the London–Manchester–Liverpool system.

In the conversion, considerable modifications were involved, including the removal of the turbine and generators with their air filter units, fuel tanks, and control gear; lowering of the roof of the gas turbine compartment to accommodate the pantograph and air-blast circuit-breaker, and remodelling and re-equipping both cabs to conform as nearly as possible to the design of the new locomotives, although the cabs in the latter will have more space.



The 'artificial load' vehicle used to give a steady current in the overhead line for testing purposes

The pantograph and circuit-breaker are of the same type as those which will be fitted both to the new locomotives and the new multiple-unit trains; future locomotives will, however, have two pantographs instead of the one carried by E 1000.

Originally, the locomotive had a Co-Co wheel arrangement, and the original bogies have been retained, but with only four of the six traction motors, so that the wheel arrangement is now AIA-AIA. Leading particulars are:

Continuous rating 3500 hp
Weight in running order 105 tons
Maximum service speed 90 mph (145 kmph)
Maximum tractive effort 40,000 lb (18,144 kg)
Continuously rated tractive effort 18,500 lb (8392 kg).

The four traction motors are separately ventilated 4-pole series and interpole machines, rated at:

Continuous — 525 A, 1000 V
One hour — 620 A, 1000 V.

In place of the original gas turbine and its associated auxiliaries are now the main transformer and rectifier. The former consists of two transformers in one tank—an auto-transformer with 38 taps to feed a step-down transformer, which in turn supplies the main rectifiers. The auto winding is tapped at 800 V to provide train heating, and at 240 V to supply the auxiliary motors and auxiliary transformer.

The ht tap-changing unit and control gear are built on to the side of the transformer tank, the tap changer being immersed in oil to reduce the clearances required. The transformer is forced-oil-cooled, the oil being pumped by a special oil-immersed pump motor unit through the original fan-cooled turbine lubricating oil cooler.

The transformer incorporates a voltage change-over switch, which alters the supply tapping on the auto-transformer to correspond with the main incoming voltage at either 25 kV or 6·25 kV. The change-over switch is automatically controlled by an automatic power control (APC) system which consists essentially of a track magnet, a receiver on the bogie of the locomotive, and a line voltage transformer which feeds a number of voltage selecting relays.

The Hackbridge & Hewittic mercury arc rectifiers consist of sixteen 4-anode glass bulbs connected in bi-phase to provide the supply to the traction motors, the normal load being distributed between the bulbs by anode compensators. Direct current excitation is used because of greater stability with the voltage variation experienced in traction. The continuous rating of the rectifier is 2800 A at 975 V, and each bulb is cooled by a 1200 cu ft (34 cu m) per minute fan.

A smoothing choke is connected between each traction motor and the main rectifier to limit the ripple current delivered to the motor. These chokes are of the iron-cored type, insulated with class H insulation and air-blast cooled.

The auxiliary transformer, rated at 65 kVA, is oil-filled, naturally cooled, and mounted on the locomotive under frame. Its main load is a bridge-connected germanium rectifier unit which feeds the 110 V dc auxiliary motors, the control circuits and lighting, and charges the battery.

The control equipment operates at 110 V dc and 70 lb/in² (4·9 kg/cm²) air pressure. It incorporates the essential dc equipment of reverser, motor contactors and overloads, and controls for the ht tap-changing system and ATC and APC equipments. It also permits the battery to be connected to the traction motors to move the locomotive when not under the contact line or when the line is dead.

Impressive Demonstration Run

The master controller in each driving cab has two operating handles: a reversing handle having three positions (forward, off, reverse), and a main handle having six positions (off, run back, notch back, hold, notch up, run up), for controlling the operation of the tap changer and main contactors. The two handles are mechanically interlocked.

Fault protection is effected by an earth leakage relay system which trips on earth fault, and a differential relay system on the auto-transformer; both trip the air-blast circuit-breaker. A switch to earth the pantograph and circuit-breaker is provided and is interlocked to avoid closure when the pantograph is raised.

The rectifiers described above are not typical of those which will be used on future ac locomotives, and the traction motors, as has been stated, were retained from the original design. With these two exceptions, the principal components of E 1000 are identical with those of the new locomotives.

On the demonstration run, referred to at the beginning of this article, the locomotive easily attained speeds in excess of 70 mph (113 kmph), hauling a load of approximately 107 tons. As might be expected, its outstanding

The First 25 kV Electric Locomotive

THE vast electrification scheme of British Railways is forging steadily ahead, but the extent and range of the work involved is so enormous that for some time to come progress must necessarily be steady rather than spectacular.

Nevertheless, events occur from tim
can justly be regarded as high-lights in
of electrification, and one of them to
end of last year, when Britain's firs
locomotive made its first run with a
the first portion of the London Midla
to be completely electrified—a 9½ mi
between Crewe and Manchester.

On this occasion, the passengers w
press and railway technical staff, an
No E 1000—will normally be used o
of drivers and the testing of equipment
of the electrification of the whole 31 m
Crewe and Manchester and the deli
locomotives now on order.

*The first 25 kV electric locomotive t
on British Railways*

By 1960, electric services on this pa
in full operation; by 1963 they will ha
Birmingham and Liverpool, and by
through electric services between Lo
Manchester, and Liverpool.

By any standards, the electrificatio
British Railways system is a gigantic
more noteworthy because, in effect, t
Region is building a new railway while
still running.

A measure of the extent of the work can be gained by what is involved even on the 31 miles (50 km) of track between Manchester and Crewe. Some 88 bridges have had to be reconstructed, tunnels opened out, a new signalling system installed, stations rebuilt, and platforms lengthened.

The bridge reconstruction programme has been necessary because the new electric services will need greater height clearance for the overhead wiring. The engineers have adopted a unique method—they have built new bridges over the old ones and blown away the former structures with explosives. Not all the bridges, however, have been dealt with in this way. In some cases it has been

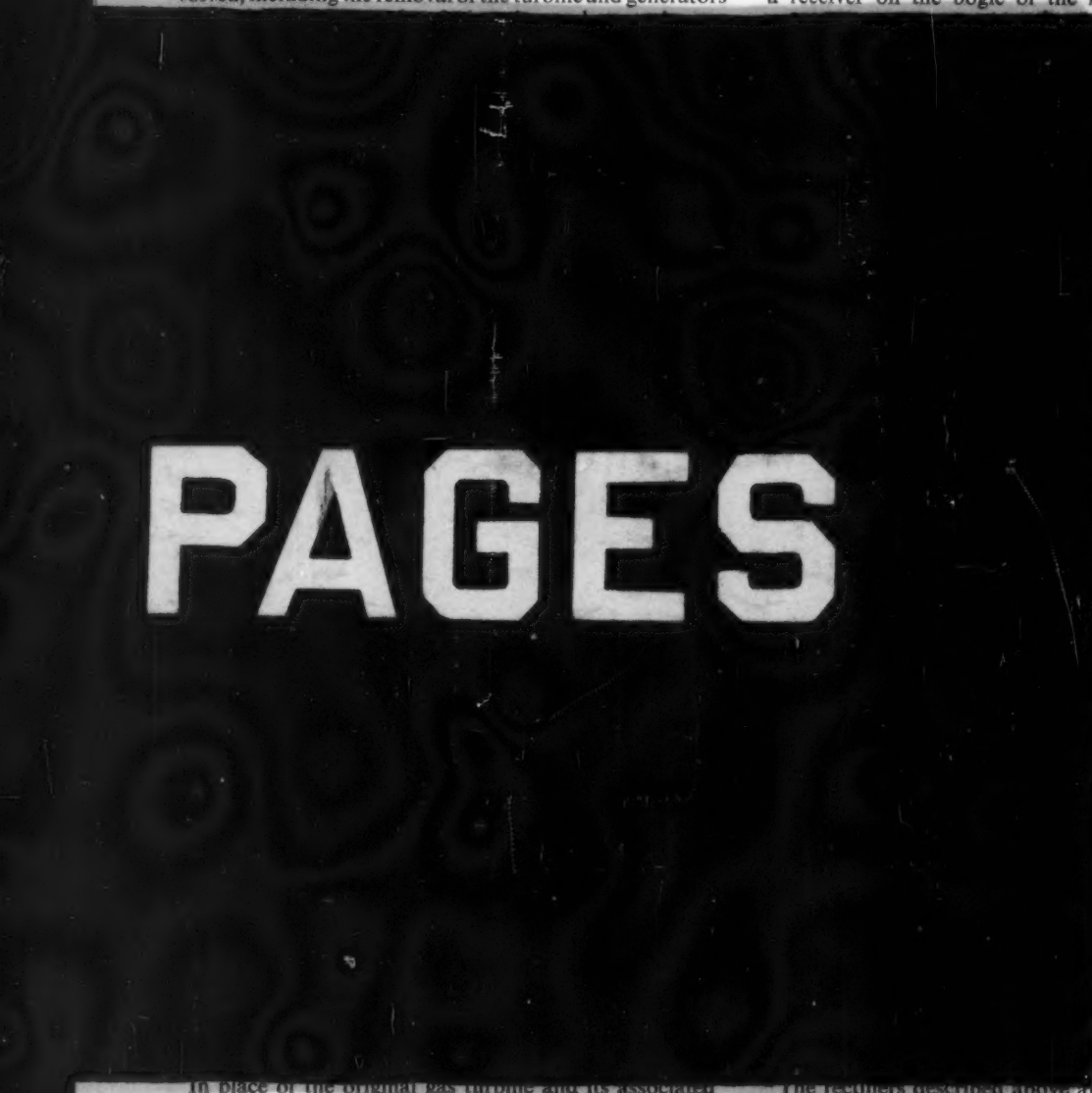
WAVY

Three types of overhead equipment have been installed on this section of line for the purpose of testing each type under actual running conditions, and work such as this will be of great value in the completion of the remainder of the major electrification schemes.

This line is also being used for training the 206 instructors and motormen and the 88 guards required to operate the Crewe to Manchester service, and this, as mentioned earlier, is the primary role of locomotive No E 1000.

This locomotive has an interesting history. It was originally built by the Metropolitan-Vickers Electrical Co Ltd as a gas turbine locomotive, and ran experimentally on the Western Region. It has now been converted by its makers, on the order of British Railways, as the first traction unit for the new 25 kV ac system, pending the completion of the 100 new Bo-Bo locomotives which Metropolitan-Vickers are now building for the London–Manchester–Liverpool system.

In the conversion, considerable modifications were involved, including the removal of the turbine and generators



In place of the original gas turbine and its associated auxiliaries are now the main transformer and rectifier. The former consists of two transformers in one tank—an auto-transformer with 38 taps to feed a step-down transformer, which in turn supplies the main rectifiers. The auto winding is tapped at 800 V to provide train heating, and at 240 V to supply the auxiliary motors and auxiliary transformer.

The ht tap-changing unit and control gear are built on to the side of the transformer tank, the tap changer being immersed in oil to reduce the clearances required. The transformer is forced-oil-cooled, the oil being pumped by a special oil-immersed pump motor unit through the original fan-cooled turbine lubricating oil cooler.

The transformer incorporates a voltage change-over switch, which alters the supply tapping on the auto-transformer to correspond with the main incoming voltage at either 25 kV or 6·25 kV. The change-over switch is automatically controlled by an automatic power control (APC) system which consists essentially of a track magnet, a receiver on the bogie of the locomotive, and a line number of voltage

ry arc rectifiers con-
nected in bi-phase to
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is used because of
ation experienced in
he rectifier is 2800 A
1200 cu ft (34 cu m)

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at 65 kVA, is oil-
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ridge-connected ger-
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s at 110 V dc and
It incorporates the
motor contactors and
tap-changing system
so permits the battery
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line or when the line

driving cab has two
dle having three posi-
ain handle having six
, hold, notch up, run
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re mechanically inter-

n earth leakage relay
nd a differential relay
oth trip the air-blast
the pantograph and
interlocked to avoid
ed.

The rectifiers described above are not typical of those which will be used on future ac locomotives, and the traction motors, as has been stated, were retained from the original design. With these two exceptions, the principal components of E 1000 are identical with those of the new locomotives.

On the demonstration run, referred to at the beginning of this article, the locomotive easily attained speeds in excess of 70 mph (113 kmph), hauling a load of approximately 107 tons. As might be expected, its outstanding

features were its high rate of acceleration coupled with extreme smoothness.

New Diesel-electric Locomotive

Another railway occasion was the début of the first of 20 new 1200 hp diesel-electric locomotives now being supplied at a rate of one a month by Metropolitan-Vickers Electrical Co Ltd for fast freight and passenger services on the lines from London (St Pancras) to the Midlands and the North.

Metropolitan-Vickers have been responsible for the design of the whole locomotive and are supplying all the electrical equipment. Brief details are as follows:

The wheel arrangement is Co-Bo.

The diesel engine is a Crossley two-cycle engine with 8 cylinders in vee formation, bore and stroke being 10·5 inches (267 mm) by 13·5 inches (343 mm); BS rating is 1200 hp at 625 rpm.

The main generator, directly coupled to the engine, supplies power to five nose-suspended axle-hung series-wound traction motors, each driving one axle. Ratings are: generator—750 V, 1070 A dc, 625 rpm; traction motor continuous rating: 475 V, 330 A dc, 180 hp, 510 rpm; traction motor gear ratio 15 : 67.

The auxiliaries absorb 60 hp, leaving 1140 hp available for traction, giving the following performance figures: maximum tractive effort at rail 50,000 lb (22,680 kg); continuous tractive effort at rail 25,000 lb at 13·5 mph (11,340 kg at 22 kmph).

A demonstration run was arranged with the new locomotive hauling a passenger train from London to St Albans—a distance of 20 miles (32 km). The outward journey was made comfortably in 22 minutes—3 minutes better than the fastest scheduled steam-hauled express train, while the return journey cut 4 minutes off the steam-hauled time.

The ACE Computer at the NPL

ONE of the world's largest and fastest electronic computers—ACE (or Automatic Computing Engine)—is now in operation at the National Physical Laboratory, Teddington, Middlesex. It is the end-product of research which began in the Mathematics Division of the NPL under the late Dr A. M. Turing, FRS, who, with his colleagues, produced in the early post-war years a logical design for a computer intended to carry some of the load of numerical calculation.

A special section—now the Control Mechanisms and Electronics Division of the NPL—was later set up to carry out the development of the machine, and in view of its size and complexity it was decided to build first a pilot model, only one-sixth of the size of the present ACE. It was completed in 1951, and during its five years of activity at the NPL (it was presented to the Science Museum in 1956) it carried out a considerable amount of work, including extensive calculations to discover the cause of failure in the early Comet aircraft. It also led to the commercial production of the English Electric DEUCE. (See page 36 of this issue.)

The present full-scale ACE—which can be described as the second generation of computers—has increased operating speed, larger storage capacity, and many additional functional facilities, making it a considerable advance on its predecessors. It is a serial computer in which the numbers and instructions have 48 binary digits (equivalent to 14 decimal digits); the digit rate is 1·5 million a second, giving a word time of 32 microsecs. The main working store consists of 24 mercury delay lines of 32 words each, circulating in a major cycle of 1024 microsecs and giving an access time of 1 millisec. Rapid access storage is provided by mercury delay lines of one, two, and four words' capacity.

The backing store is provided by four magnetic drums, entirely designed and constructed at the NPL, and possessing some particularly interesting features. The total capacity of the store is equivalent to 1024 long delay lines, *i.e.* 32,768 words or about 1·5 million digits. Each drum has 16 'read' and 16 'write' heads, and by moving the heads as one unit into one of 16 discrete positions, 256 tracks are obtained on each drum, each track storing the contents of one delay line. The drums are 6·75 inches (172 mm) long by 5 inches (127 mm) diameter, allowing a linear digit packing of 100 to the inch (25·4 mm).

The drums are driven by hysteresis motors running synchronously at 12,000 rpm and phase corrected so that they rotate exactly once in five major cycles of the machine, which means that a magnetic spot 0·01 inch (0·254 mm) in length and travelling at the rate of 200 miles (322 km) an hour must arrive at a given point with an accuracy of 1 microsec.

Punched card input and output have been provided initially, running at 450 and 100 cards a minute respectively, but magnetic tapes will be added later.

ACE is housed in 10 cabinets, each with a cooled air-circulation system. Access to the 24 chassis units housed in each cabinet, incorporating a total of about 6000 valve envelopes, is provided by automatically controlled rising doors.

Since the present ACE was designed, new techniques in electronic switching and storage have been developed, and these advances will no doubt be used in the third generation of computers which are now being designed. A notable technique which will save space and eliminate most of the cooling problems is the use of the cryotron, a form of semiconductor device operating at very low temperature in liquid helium, which shows promise of being particularly useful in memory cells and has the additional advantages of small size and high speed.

The total cost of ACE was in the order of £250,000—a very favourable figure compared with the cost of hiring from the USA a computer capable of meeting the requirements of the National Physical Laboratory, said to be about £200,000 a year.

Britain Wins International Welding Award

A PAPER on 'The Application of Stud Welding to Vibrating Wire Strain Gauges' by Dr J. C. Chapman, of the Civil Engineering Department of the Imperial College of Science and Technology, London, has won the second annual Gregory Award. This 1500 dollar award is presented for the year's most outstanding contribution in the field of semi-automatic electric arc stud welding, and is sponsored by Gregory Industries Inc of Loraine, Ohio, USA, who are licence associates of Crompton Parkinson (Stud Welding) Ltd.

Dr Chapman's paper describes how strain gauges were stud welded to the structural members of the new Mechanical Engineering Building at Imperial College—the first building in Great Britain in which the floor beams are castellated, have reinforced beam flanges, and are designed for composite action with the floor slabs, using stud welded shear connectors to couple the slabs at the top flanges of the beams. In this way the floor slabs make a considerable contribution to the strength of the structure and permit a considerable saving in steel.

Vibrating-Wire Gauges Chosen for Long-Term Stability

The unusual nature of the building led to the decision to make a record of the structural behaviour, and this required that strain measurements should be taken through all the building stages and during the life of the building. Therefore the strain gauges used had to be stable over a long period, and with this in mind acoustic or vibrating-wire gauges were selected, comprising a steel wire in tension over a magnet assembly with a robust metal cover over all.

This type of gauge uses the variation with tension of the natural frequency of vibration of a taut steel wire to indicate changes in strain. In this instance the wire is 'plucked' by means of an electromagnet, the same magnet then acting as a 'pick-up' to signal the free vibration of the wire to an oscilloscope. A calibrated frequency source can be compared with the frequency of the strain gauge, and the change of strain in the structure to which the wires are attached can thus be determined by the change in frequency.

The long-term accuracy of the gauge will be correct, even if the strain alternates between tension and compression, as long as there is no relative movement between the wire gauge posts and the structure. One-thousandth of an inch (0·0254 mm) on a 6-inch (152 mm) gauge length would give an error of stress of more than 2 tons per square inch (311 kg/cm²).

One of the causes of strain gauge inaccuracy in earlier designs has been that the posts moved after the wire had been attached. To overcome this, Dr Chapman stud welded the posts to the beams, thus making them integral with the structure.

Other factors in favour of stud welding were that the magnet assembly could be suspended from two threaded studs placed below the wire, so that the clearance between the electromagnet and wire could be accurately adjusted; and that a robust and simple anchor for the cover could be provided by stud welding two fixing studs to the beam. When the cover is in place, the strain wire is insulated from the atmosphere and takes up the same temperature as the structure; it is therefore self-compensating for temperature.

A single template was used to assist the installation work and enabled all six studs to be located without difficulty and with very high accuracy.

The gauge posts are $\frac{5}{8}$ inch (0·625 mm) diameter studs, $1\frac{3}{4}$ inches (44·5 mm) long with a $\frac{1}{8}$ inch (0·125 mm) slot milled to accommodate a $\frac{1}{2}$ by $\frac{1}{8}$ inch (0·5 by 0·125 mm) pressure bar which clamps the wire between the bar and the bottom of the slot. After being accurately tensioned, the wire is clamped at the posts by the clamp bar, which is held by concentric screws giving uniform pressure across the whole diameter of the stud. The free length of the wire is thus known precisely.

Correct alignment of the gauge posts before welding was assured by a tongue, within the chuck of the welding hand tool, which locates in the slot in the post, and correct location of the hand tool in the template was assured by using three holes in the template aligned with three studs in the tool. The same template was used for all six studs and in consequence all the components were correctly secured in relation to the wire and to each other.

More than 142 Gauges Assembled, Adjusted, and Stud Welded

The cast-iron cover is sealed and isolated from the structure by a rubber gasket and from the fixing studs by rubber grommets and washers, and means are provided for connecting an armoured cable to the leads from the electromagnet after the cover has been fixed and sealed to the beam. Strain readings for checking purposes could thus be recorded before the covers were fitted, and the armoured cable could be connected at any convenient time during erection. A paxolin terminal board carrying a tube of silica gel as a drying agent is mounted on the rubber sealing gasket, and when the cover is placed in position this board fits into grooves on the inside of the cover which are filled with a non-hardening sealing compound.

Using Crompton Parkinson 'Cyc-Arc' stud welding equipment, forty-two gauges were assembled and adjusted in two days to meet the steel erector's schedule, and over one hundred gauges were subsequently stud welded to the steel work before erection. All the strain gauges operated satisfactorily.

The Electronic Computer Exhibition and Symposium

THIS event—the first of its kind ever to be held in Europe—took place in London at the end of November and the beginning of December 1958. It consisted of three separate, though related, operations: (1) an International Scientific Symposium on the use of computers in relation to the mechanism of human thought, organized by and held at the National Physical Laboratory; (2) an Exhibition of British electronic computers and associated input and output equipment at Olympia, and (3) a Business Computer Symposium held concurrently with the exhibition, during which 23 papers were presented and discussed during 6 sessions.*

During his speech at the opening luncheon, Mr Vernon M. Roberts, OBE, BSc, AMIEE, Chairman of the Joint Committee of the Electronic Engineering Association and the Office Appliance and Business Equipment Trades Association, made these points:

'The papers (at the Business Symposium) are not "sales talk" by computer manufacturers, but practical papers mainly by users of experience covering a wide field of application.

'The National Physical Laboratory and the manufacturers belonging to the two associations have worked harmoniously together to demonstrate to the world that Britain has developed and can supply equipment, backed by applicational experience, to satisfy any home or export requirement.'

Trends at the Exhibition

Over 40 manufacturers of computers and directly ancillary equipment were showing and demonstrating their products, and a review of the exhibits of the 10 BEAMA member-firms is given below.

It is natural that the design and production of such large and expensive equipment as computers, calling for a very great capital investment, and demanding extremely high standards of technical and manufacturing skills and wide resources, should reside largely (though by no means exclusively) with the big firms in the electrical and electronic industry. Furthermore, it is only within the last very few years that the full significance of the part that the computer can play in the industrial, commercial, and economic life of highly developed countries has come to be realized. This impressive and busy exhibition was visible evidence of the great strides made by the industry in so short a time.

It also emphasized the great technical advances which have been made in British computers in these few years, and the technical leadership which is being established by the British electronic and business equipment industries.

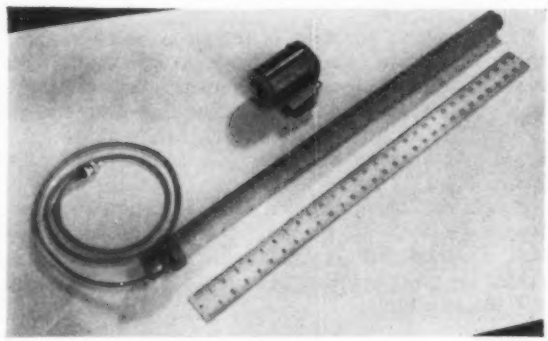
Notable trends are the increased flexibility of the equipment, which in turn leads to more versatile methods of working; faster operation, and—above all—an extremely high standard of reliability. Factors in these trends include the increasing use of transistors instead of valves—a direct contribution to greater reliability, as well as making for smaller dimensions, lower power consumption, and much reduced heat dissipation.

The most important advances are, however, in the development of greatly improved and much larger memory storage systems—magnetic drum, magnetic tape, and ferrite cores—in conjunction with very much faster access times. Side by side with these developments have come better and faster input and output equipment, since the high-speed arithmetical working of the computer is necessarily conditioned by the rate at which information can be fed into it and the rate at which its electrical output can be converted into readable intelligence.

Thus the earlier typewritten output at about 70 words a minute has given way to punched tape output at some 300 words a minute, while new equipment introduced and shown at the exhibition includes a new reader capable of 3000 words a minute, and another new system now being developed—xerography, or electrostatic printing—for which a speed of 3000 *lines* of type a minute will eventually be realized.

On the input side, there are at least two electronic 'readers' or scanners which can scan typed, or even handwritten, pages and convert them to suitable electric impulses for acceptance by a computer.

Programming is a large and important part of any computer operation. With the ever-expanding application of computers, several manufacturers are building up extensive libraries of programme routines and subroutines which are available to users. Alternatively, in cases where the work available in a firm is not sufficient to justify the purchase of a computer, computing services are available from several manufacturers. Firms can either rent time on the computer at a fixed rate per hour, with, of course, access to the manufacturers' library of programmes and routines, or a problem will be accepted by the computer manufacturer, who will provide the



BTH Helisyn position control, showing the Helisyn bar and the sleeve transducer. The scale (shown for comparison) is 30 in (76 cm) long

* THE BEAMA JOURNAL, November 1958, p 176.

answer, carrying out any new programming that may be necessary. In both cases the existence of the programme libraries can materially reduce the costs of the operation.

Some Exhibits Reviewed

Electronic control of machine tools was the principal feature of the exhibit by the BRITISH THOMSON-HOUSTON CO LTD. This is a field in which the company have done considerable pioneer work, and one of the recent developments shown here was the coordinate position setting system operating from punched card input. Two sets of coordinates are fed in simultaneously from a card and 'sensed' by a mechanical card-reader; the setting dials are then automatically positioned by electronic control and the set dimensions are displayed on the dials for checking purposes, if required.

The most interesting exhibit here was the Helisyn position control device which is now in course of development. Its purpose is precision linear mechanical positioning in response to numerical input, with special application to such operations as machine tool control and automatic inspection.

The Helisyn consists of a short cylindrical member which is movable along—but is not in contact with—a longer cylindrical member, each of them carrying conductive paths in the form of interlaced helices. One of the elements is excited electrically by appropriate voltages set up in accordance with the numerical input, resulting in the appearance of an electrostatically induced misalignment signal in the other element.

For the demonstration, laboratory apparatus was used, arranged to accept a decimal input defining a position to 0·0001 in (0·0025 mm) and showing that the combination of the digital-to-analogue converter with the Helisyn can be used to achieve mechanical positioning to an order of accuracy consistent with that of the input.

One of the largest stands in the exhibition was taken by ELLIOTT BROTHERS (LONDON) LTD (members of the Elliott-Automation Group) in association with the National Cash Register Co Ltd and Panellit Ltd to show a wide range of computing and data processing equipment.

One of the principal exhibits was the 402F floating-point scientific digital computer with paper tape input and output, similar to the equipments recently delivered to the Ernst Leitz Optical Works in Germany and to the Physics Division of the Research Department of the British Transport Commission. It is stated that these are the only two such machines in Europe.

The 402F is a general-purpose automatic binary computer designed primarily to tackle scientific and engineering problems in which the mathematics are either too complex or too lengthy to be performed by desk machines. It also considerably reduces the time taken in the comparatively straightforward computational work which is a feature of research.

This computer has a medium-sized memory which enables it to store and perform operations on over 4000 numbers simultaneously. An additional feature is that floating-point arithmetic can be used; this permits greater accuracy in a far bigger range of numbers. The speed of the computer is such that pairs of numbers, each of nine digits, can be multiplied at the rate of 300 a second.

Another feature of the stand was the 802 'Compudesk' —a prototype general-purpose digital computer which strikingly shows how the use of transistors, printed circuits, and magnetic cores has enabled dimensions, weight, and power consumption to be reduced. The 802 combines the versatility of much bigger machines with an overall size not much greater than that of an office desk, while special cooling and ventilation arrangements are not needed.

It is claimed that, by using simplified operating methods, the 802 will not require specialized programming staff and that the user will be able to programme the machine himself after only a short period of instruction.

The basic 802 uses punched paper tape input and output, but the design provides for specialized input and output devices, if required, such as punched card or manual keyboard input, analogue and digital recording mechanisms, and so on.

A comprehensive library of sub-routines is available.

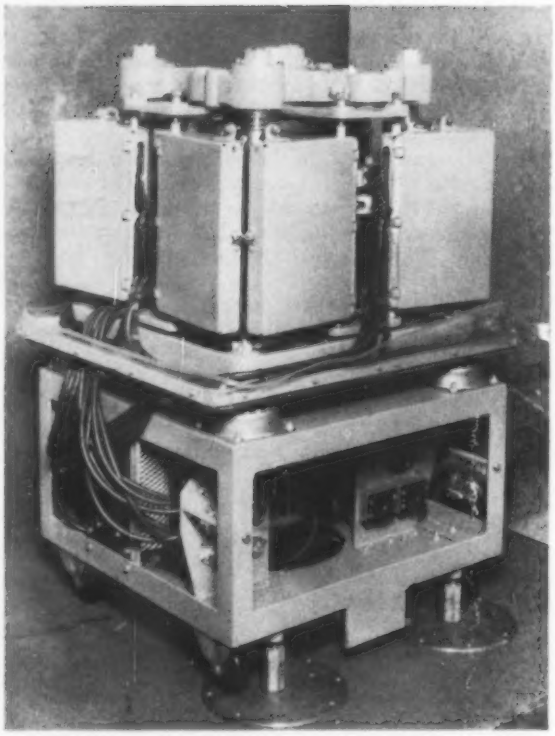
It is claimed by EMI ELECTRONICS LTD that some of the most advanced computers ever shown in Europe were to be seen for the first time on their stand.

The Elliott 402F floating-point computer

In their range of 'Emidec' digital computers, the 'Emidec 1100' is a high-speed machine employing the latest construction techniques and, with its associated input and output equipment and high-speed magnetic tape units, constitutes a comprehensive and flexible data processing system covering a wide range of applications. It has been designed for maximum reliability and uses magnetic cores and transistors throughout; construction is on the unit principle, which enables each unit to be independently made and plugged in to form a complete machine.

Operation is in the binary mode, with a fixed word length of 36 binary digits. Automatic conversion to and from the binary code is provided with all peripheral units. Data stores comprise: (1) a 1024 word immediate access store of magnetic cores interlaced to form a matrix; (2) magnetic drums of 8192 or 16,384 words which provide the main internal store, and any number of drums within reasonable limits can be used; (3) high-speed magnetic tape decks with a tape storage capacity exceeding 13 million binary digits, or 2·5 million alphanumeric characters, with a very fast read/write rate of 20,000 characters a second.

A variety of input and output equipment is available, which may be in sterling, decimal, or alphanumeric form.



One of the Emidata magnetic drum stores produced by EMI Electronics Ltd. They are high capacity units of 8000 or 16,000 words

Too large to show in its entirety is the Emidec 2400 which is now in an advanced stage of construction in the main EMI factories. When completed, this computer, the development of which has been sponsored by the National Research Development Corporation, is claimed to be one of the most advanced data processing systems in the world. It is a general-purpose high-speed computer with both on-line and off-line peripheral equipment, and embodies many new features to simplify programming and to handle large volumes of data. Special features are that many operations—such as input/output and computing—proceed in parallel by means of a time-sharing system which makes maximum use of the high-speed inherent in the central computer; another is a versatile programme interrupt feature which allows a large installation with many peripheral units to be automatically programme-controlled.

Another section of the stand was devoted to analogue computers, and the Emiac II—a general-purpose analogue computer of advanced design—was demonstrated on actual problems typical of those occurring in science and industry.

The introduction of a series of Emidata components indicated a new line of development. These are being produced to meet the needs both of the EMI Computing Division and of other firms requiring electronic equipment and ancillary data processing equipment.

Two items were shown. One was a fast start/stop digital tape deck for 1 in (25·4 mm) tape, in which bi-directional tape speeds of 200 in (508 cm) per second, with start and stop times of 4 milliseconds, have been achieved by an advanced design of vacuum capstan. The deck accommodates 2400 ft (730 m) spools with up to 24 channels.

The other equipment was an instrumentation tape deck designed for the requirements of the data processing engineer. It provides 4 or 6 tape speeds and up to 24 channels on 1 in (25·4 mm) tape. Four of its speeds within the range of 0·5 to 120 in (1·27 to 305 cm) per second can be selected instantaneously.

A range of magnetic drum stores and magnetic heads has also been produced.

Emitape (magnetic recording tape) and Emifilm (sprocketed magnetic recording film) were shown on another stand by EMI SALES AND SERVICE LTD. Emitape for instrumentation use can be supplied in widths increasing from 0·25 to 1 in (6·35 to 25·4 mm) in 0·25 in (6·35 mm) steps, and from 1 in (25·4 mm) upwards, increasing by 1 in (25·4 mm) steps, and in nominal lengths of 600, 1200, 2400, and 3600 ft (183, 366, 730, and 1097 m).

Emifilm, designed for cinematographic, telecine, and industrial applications where absolute accuracy of synchronism is required, is supplied in 16 mm sound or silent film negative or positive raw stock, either single or double perforated, and in 35 mm positive raw stock.

A particularly interesting exhibit on this stand was the drop-out and noise test equipment used in the factory for checking the magnetic uniformity of every piece of instrumentation tape.

The test method uses a full-width recording of square-wave current pulses made by passing equal positive and negative currents through the recording head for equal times without return to zero, at a rate which produces 200 complete reversals per in (25·4 mm) of tape. The value of the current pulses in each direction is adequate to saturate the tape.

Two multi-track reproducing heads are so disposed that their tracks interlace and scan the entire surface of the tape under test. The outputs from the two heads are processed electronically and the incidence of lost pulse and drop-out—defined as the failure of the reproduced pulse to reach a level 6 db below that of the standard reproducing amplitude—is shown on dekatron counters. By comparing the drop-out count with that of individual pulses lost, the average drop-out duration can also be determined.

The well-known Deuce (Digital Electronic Universal Computing Engine) provided the chief feature on the stand of THE ENGLISH ELECTRIC CO LTD. Developed from the original Ace pilot model built by a combined team of electronics engineers and mathematicians from the National Physical Laboratory and the English Electric Co Ltd, Deuce was applied initially as an aid to scientific and technical calculations; hence the emphasis in its design was on the high-speed solution of long and complex problems.

Various modifications were later made to increase the capacity and speed of its input and output, and to increase the size of the high-speed store, so meeting the ever-expanding requirements both of scientific applications and commercial data processing. Hence the latest versions of the equipment shown at the Exhibition: Deuce Mk I, Mk II, and Mk IIA.

The Mk I version uses 64 of the available 80 columns of a punched card, as against the 32 columns of the original Deuce, thus virtually doubling the input and

output speeds. It also has provision for using magnetic tape as an auxiliary storage medium, if required.

Deuce Mk II was developed specifically to form the central unit of a commercial data processing system. It therefore incorporates a combined input/output machine, completely buffered, capable of reading all the 80 columns of the standard punched card, and it is normally fitted with magnetic tape auxiliary storage equipment. Lastly the Deuce Mk IIA, which has an additional feature of a high-speed store with 50 per cent greater capacity.

Deuce is a serial machine operating in the binary mode, and has a pulse repetition frequency of 1 Mc/s. It uses a word length of 32 digits and a word time of 32 microsecs. Multiplication and division times are 2 millisecs, and addition and subtraction times 32 microsecs per operation. The high-speed store immediately associated with the computing circuits uses mercury delay lines and accommodates 402 words, and the backing store is a magnetic drum of 8192 words on 256 tracks of 32 words each. In the Mk IIA are seven extra long delay lines, increasing the total high-speed store to 626 words.

Auxiliary magnetic tape units, when fitted, are of the twin transporter type (*i.e.* two tape units in a single console), and up to 4 of them can be accommodated on the standard Deuce equipment. A feature of the magnetic tape system is the facility for varying the block length, *i.e.* the amount of information written on to the tape at full speed without interruption; a facility which helps to achieve compact storage without sacrificing flexibility.

The company has built up over the years an extensive library of programmes and sub-routines covering a wide field of applications, all of which are fully available to Deuce owners and users. Care has also been taken to ensure complete compatibility between the Mk I and Mk II versions and the original Deuce, so that all the machines can take full advantage of the library. The company also operates two 'Time-Hire' centres—one at the Research Laboratories at Stafford and the other at the London Computing Centre; at both the programme library is available to all time-hire users.

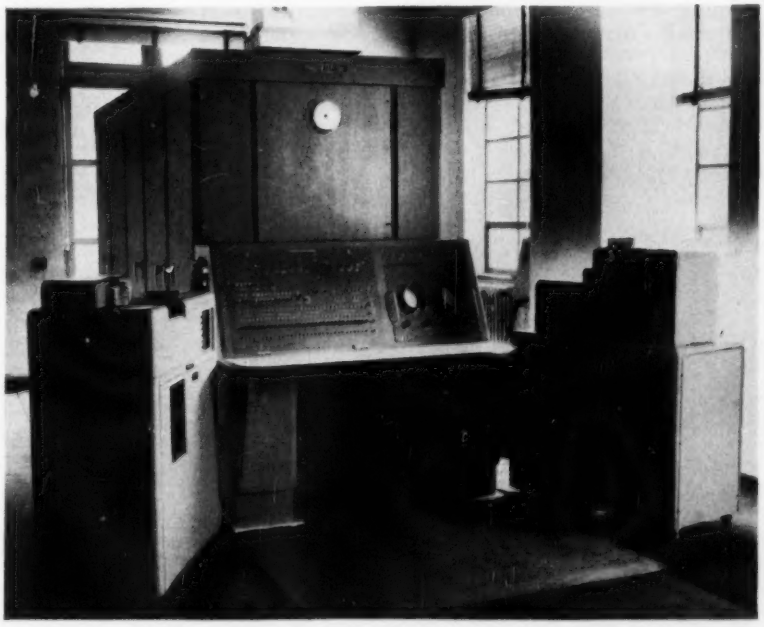
Analogue equipment was represented on the stand by Lace Mk II (Luton Analogue Computing Engine)—a versatile high-speed analogue computer originally developed for the company's own research requirements, and subsequently re-engineered and introduced as a commercial product. It has been designed as a completely self-contained equipment with its own power supplies, amplifier units, multipliers, function generators and wave-form generators, and is capable of dealing with up to twelfth order problems.

As befits one of the pioneers in the computer field with an impressive record of sales both at home and overseas, FERRANTI LTD had an extremely comprehensive range of equipment on show, including three types of computers; a computer control system for machine tools; a range of ancillary equipment, and a presentation of several new techniques to assist the smaller organizations using a computing centre and hiring the equipment for perhaps only a few minutes or hours each week.

In designing their computers, Ferranti have distinguished between the needs of external and internal business requirements. In the first category are, for example, large organizations having extensive dealings with the public—such as insurance, banking, central and local government, public utility undertakings, and so on—involving millions of items and many thousands of documents to be printed periodically, and calling for maximum speed of processing and output. The Perseus data processing system shown for the first time at the Exhibition has been specifically designed for such work.

Perseus is the largest data processing system so far produced in Western Europe, and the first two models will be used by insurance companies in South Africa and Sweden for maintaining hundreds of thousands of policy records. Chief features and facilities of Perseus include: up to 2048 words of 12 alphanumeric characters; mixed radix arithmetic (direct handling of sterling and decimals); field selection, for operating on parts of a 12-character word; 16 magnetic tape units controlled through 4 buffer stores, for simultaneous processing; built-in checks of all arithmetic and magnetic tape operations; two punched card inputs, each of which can be of any punched card type; paper tape input and monitoring teleprinter; off-line magnetic-tape-operated Samastronic printer.

In the internal category, there are problems—such as stock control, piece parts and work in progress records, sales analyses, etc.—where the operations involve rather more calculation and less administrative routine than in the previous category. For this type of work, calling for large storage and fast computation combined with the ability to handle complicated card layouts and variable



The English Electric Deuce computer recently installed at Bankside House, the headquarters of the Central Electricity Generating Board

length file records, the Pegasus data processing system was shown as a working model in a typical installation. Altogether, three Pegasus systems are available, as follows:

The Pegasus converter system, which gives up to 7000 words of 39 binary digits capacity (11 decimal digit equivalents); built-in facilities for converting punched card images on magnetic tape into binary words, and vice versa; off-line printing on a 150 lines per minute alphanumeric printer; selective printing facility for off-line printing of selected items; off-line card-to-tape and tape-to-card conversion.

The Pegasus direct data processing system, which has direct card input and card punch output; facilities for handling all types of punching to be found on cards; provision for use with an off-line magnetic tape Samastronic printer; built-in facilities for converting punched card fields into binary words, and vice versa; up to 16 magnetic tape units.

The third is the Pegasus common language processing system for commercial problems in industry and commerce, where data are created by accounting machines. This version comprises a Pegasus computer with a 7000 word main store and 4 magnetic tape units giving: 300 characters per second paper tape input from accounting machines; 240 characters per second paper tape output from a fast punch; very high-speed sorting, using the main store and the magnetic tapes; efficient verification of teleprinter transmitted data.

The Ferranti Mercury is claimed to be the largest and fastest electronic digital computer made in Europe. It has been ordered by seven nuclear authorities for research work in both physics and engineering. It is particularly suited to large-scale planning and technical calculations, and to large linear programming operations. Among its features are: very large storage capacity—1024 words in the immediate access store, and 16,384 words on magnetic drum storage; full magnetic tape, punched card, and line printing auxiliary equipment; built-in floating-point arithmetic; parity checks throughout the system; the most comprehensive autocode scheme on any European machine, and extremely high speed.

Digital differential analyzers have been used by Ferranti over the past seven years to record programmes for their computer-controlled machine tools, but the techniques can be used to solve any continuous computing process in such typical applications as simulators, computers for process control, and accurate multipliers and axis transformers for analogue differential analyzers. In the more simple analyzers, the digital differential output can control directly a digital plotting table for two-dimensional graphical display with high accuracy.

This last-mentioned unit can also operate from a suitable input as an automatic drafting machine, and in this connexion the Ferranti computer service can be used.

METROPOLITAN-VICKERS ELECTRICAL CO LTD showed a scale model of their new 1010 computer which is due for completion by the middle of this year; the 950 computer; the 960 paper tape reader; and a centralized monitoring and control system including analogue-to-digital conversion.

The new 1010 is a fast transistor-operated computer with parallel arithmetic circuits, magnetic core working store, and a variety of ancillary equipment, designed for data processing and real-time process control, and also capable of solving complex scientific and engineering problems.

The fast arithmetical and control unit operates in the parallel mode and carries out typical data processing programmes at a speed of some 50,000 simple address instructions per second. Word length is 44 digits and contains two 22-digit instructions; a B line has 13 digits and can perform limited operations. The instruction code is very flexible and covers a wide range; both fixed point and floating point calculations can be performed.

The immediate-access store holds either 2048 or 4096 words in a 3-dimensional array of ferrite cores; each word may contain two computer instructions, a 13-digit decimal number, or a group of coded alphabetical characters. Auxiliary storage is provided by two types of magnetic drum store and a magnetic tape store.

A wide range of ancillary equipment is available, including high-speed input and output apparatus. Up to 32 units can be added, each operating at its optimum speed by using a small buffer store to isolate it from the computer.

A novel feature is the data scanner, which transfers information between the magnetic core store and all ancillary equipment. It interlaces the transfers automatically word by word with the execution of computer instructions and can maintain simultaneous transfers of blocks of data to or from all ancillary equipment. This allows the on-line connexion to a very fast computer of relatively slow peripheral equipment without delaying computation.

The instruction code provides facilities for the parallel operation of a number of programmes having com-

The Ferranti Perseus data processing system. In the centre is the basic computer. At the back left is the power supply and at the back right the magnetic tape and punched card control units. The magnetic tape units are in the left foreground and the punched card readers in the right foreground

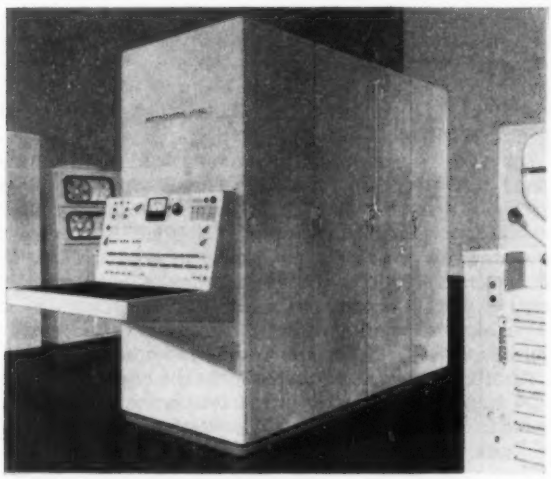
patible storage requirements, and programmes can be interrupted to execute another programme of high priority.

The Metrovick 950 general-purpose computer has been designed to meet the requirements for a reliable medium-speed computer at a price which is attractive to small firms, universities, and technical colleges.

It comprises input and output equipment, store, arithmetical circuits, and control unit. Input is by a photoelectric reader for a 5-hole code punched paper tape; the store is a magnetic drum, and output is a 5-hole punched tape and printed page.

The 960 paper tape reader is a compact self-contained unit reading standard 5-channel teleprinter tape at a maximum speed of 250 characters per second. Transistors have been used throughout, thus materially reducing the size and power requirements.

Finally, the exhibit showing the Metropolitan-Vickers system for central monitoring and control represented an oil storage and distribution system.



This picture (from a drawing) shows a typical layout of the Metrovick 1010 Data Processing System, of which the first equipment will be completed in mid-1959

The main components of the system are primary measuring elements, static analogue-to-digital converters, digital data transmission, and display. The values of temperature, pressure, and level as measured on the oil storage tank were transmitted and displayed on decimal indicators in the 'control room'. This system also uses transistors throughout the electronic equipment.

In keeping with the general trend towards the use of semi-conductors in computers, MULLARD LTD were making a special feature of transistors and other devices, as well as valves and tubes, either specifically designed for, or suitable for use in, computers and allied equipment.

Among the products shown for the first time were two alloy-junction high frequency power transistors, a gold-bonded computing diode, and a range of three silicon high voltage power rectifiers suitable for valve-operated computer power supplies.

Types OC 23 and OC 24 are the new alloy-junction transistors developed especially for digital computing applications. Their chief feature is an exceptionally good high frequency performance combined with large power-handling capacity; the average cut-off frequency is 2·5 Mc/s and the collector dissipation 8 W at an ambient temperature of 45 deg C (with infinite heat sink). Thus they are suitable for several other applications besides their primary purpose of driving rectangular-loop ferrite computing elements and memory matrices.

The second item mentioned above is the OA 7, a gold-bonded germanium diode with low-hole storage characteristics intended for use with transistors in high-speed computing circuits. Peak inverse voltage is 25 V, which is adequate to withstand the ht voltages normally used with transistors, and the maximum forward current is 50 mA (peak or mean).

The three silicon high-voltage power rectifiers are types OA 210, OA 211, and OA 214, having respectively peak inverse voltages and maximum currents as follows: 400 V and 500 mA; 800 V and 400 mA; 700 V and 500 mA.

Interesting demonstrations showed how transistors may be used to control and drive a ferrite store operating at a repetition frequency of 100 kc/s, and how standard 'packages', each containing diode-resistor logical networks and pulse regenerative amplifiers, may be used to construct a serial adder-subtracter unit operating at a digit frequency of 1 Mc/s.

Also demonstrated was the equipment developed for the automatic testing of Ferroxcube rectangular-loop cores used for magnetic memory matrices in high-speed random access storage systems. Three cores are available in planes of up to 32×32 or 64×64 cores, or in stacks containing any number of planes, wired, fully tested and mounted in standard boxes as complete assemblies. Two examples were shown: one with 40 planes containing 4096 cores giving a total storage capacity of 163,840 digits; the other with 40 planes of 1024 cores and a capacity of 40,960 digits.

On a near-by stand, MULLARD EQUIPMENT LTD exhibited a high-speed analogue-to-digital converter, a new variable wire delay line, and an industrial sequence control.

The converter was designed for converting at high speed an analogue input voltage into a binary output of 10 bits, available in parallel or sequentially and in true binary or binary-coded decimal form. The sampling period is less than 1 millisec, samples being taken on receipt of input pulses which may be at any frequency up to 1000 a second. The analogue input voltage range is 0–10 V positive. For sequential output the maximum output pulse rate is approximately 12 kc/s, or it may be locked to any external source of pulses provided the prf does not exceed 12 kc/s. For parallel output, the pulse rate will be coincident with the succeeding input sampling pulse.

The variable wire delay line is a newly developed magnetostrictive wire delay line with facilities for continuous adjustment of the delay period over a wide range. Lines giving maximum delays of up to 4·5 millisecs can be supplied, incorporating (if required) input and output amplifiers and pulse re-forming circuits.

The maximum pulse repetition frequency that can be stored depends on the delay required: in a 4·5 millisec line a prf of at least 250 kc/s can be stored, while with a 1 millisec delay, 1 Mc/s is attainable. No temperature control is required, since the lines have a temperature co-efficient of delay as low as 5×10^{-6} per deg C.

A newly designed transducer is used, movement of which along the line varies the delay. A single transducer

gives a range of adjustment of 100 microsecs, but by using a number of transducers spaced along the line, the range can be extended indefinitely, and a number of signals can be produced from one line, each delayed at pre-selected intervals from the initiating pulse.

The acoustic energy generated by the transducers is propagated along the wire in the form of torsional waves. These have a lower velocity in the wire than longitudinal waves and give rise to less dispersion, so permitting a

The Mullard 1-millisec variable magnetostrictive wire delay line for use in computers at pulse repetition frequencies of up to 1 Mc/s. It is shown here with top cover removed

shorter line for a given delay and a compact spiral form of winding. A line giving a maximum delay of 1 millisec requires 10 ft (305 cm) of wire and can be mounted in a unit of only 10 by 7¼ by ½ in (25·4 by 18·4 by 1·27 cm).

In addition to their uses in computers and other electronic equipment, these lines can be used in telephone engineering for storing routing information in pulse form.

There was also featured a new system of industrial sequence switching using transistors in computer-type logic circuits, and it is claimed that it offers greater reliability than conventional systems based on electro-mechanical relays. The system is built up with basic units of universal 'AND/OR' circuits, and each unit can accommodate up to 6 input and 6 output circuits. Inputs may be derived from any kind of transducer providing the small amount of power needed to switch a transistor. The outputs provide sufficient power to operate inductive loads of up to 36 W or non-inductive loads of up to 50 W. The system is applicable to most kinds of sequence control problems.

Two other exhibits were a new high precision linear measurement transducer for machine tool control, and the 'Autoplot'—an automatic electronically controlled machine for drilling, marking-out, plotting, or draughting operations on sheet materials of any kind.

The positioning accuracy is stated to be within 0·001 in (0·025 mm) over any 6 in (152 mm) of travel, and to within 0·002 in (0·05 mm) over the entire working table surface of 30 by 20 in (76 by 51 cm).

SIEMENS EDISON SWAN LTD showed a new miniature uniselector which is claimed to be the smallest rotary selector switch yet produced. Designed as a plug-in unit to occupy the same space as a British Post Office type 3000 relay, it provides 36 outlets, weighs only 12 oz (340 grams), and is stated to operate for 2 million revolutions without adjustment.

The range of Ediswan Mazda transistors was shown in conjunction with a number of digital computer circuits typical of the applications for which the XA, XB, XC, and XD series of transistors are suitable. There was also a working demonstration of transistor-operated magnetostrictive delay lines and high-speed transistor logic circuits.

A part of the stand was devoted to examples of the precision plastic mouldings which are produced in great numbers for telephone equipment and for the electrical industry in general, with special emphasis on switch and control gear. A series of photographs showed part of the range of display indicators produced for use as arrival and departure indicators, supervisory control panels for industrial plant, and so on.

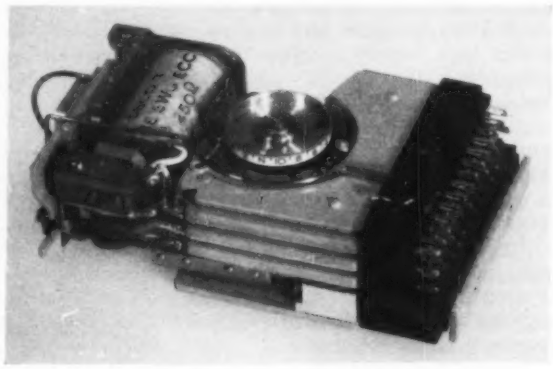
Among the many interesting exhibits shown by STANDARD TELEPHONES & CABLES LTD, the chief feature was the 'Stantec-Zebra' computer. Although it ranks among the lower-priced British-made computers, it offers great flexibility and a wide variety of applications. Designed initially by mathematicians for mathematicians, it has already been successfully applied to the solution of industrial and commercial problems—a typical one being to determine the most economical use of available raw materials in the production of a particular range of end-products. Other uses are the analyzing of aerial photographs for geographical surveys, and the calculations associated with aircraft design.

Briefly, it is a serial-binary digital computer having a word length of 33 binary digits (including 1 sign digit); a magnetic drum main store of 8192 words with a maximum access time of 10 millisecs and a word time of 312 microsecs, and 15 immediate access stores of 1 word length each.

Input is from punched paper tape with a maximum speed of 200 characters a second; one input device is normally provided but the machine can operate with several input devices in parallel, if desired. Two outputs are normally provided: punched paper tape at 25 or 50 characters a second, and direct printing at 7 characters a second. Several output devices can be used in parallel, if required, and printing devices with much higher speeds can be used as they become available.

Another feature of the exhibit was the high-speed loop tape machine, which was linked for demonstration purposes to the Xerographic high-speed printer on the stand of Rank Precision Industries Ltd.

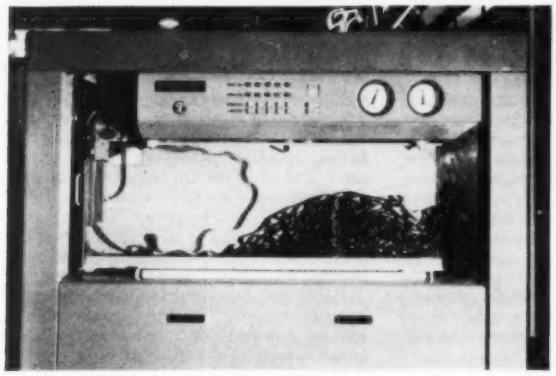
The machine is a high-speed, large-capacity binary store, and the length of the tape loop as demonstrated was about 300 ft (91 m). The tape speed is 100 in (254 cm) a second. The tape is contained in a magazine unit, and five of them can normally be fitted into the frame, although ten-unit frames are also available.



The new miniature uniselector by Siemens Edison Swan Ltd showing (left to right) *mechanism, contact bank, and pre-wireable jack*

Twelve tracks of information can be written on to the tape, some of them being clock tracks for timing control. Information is stored in blocks, and in this demonstration each block contained a maximum of 500 binary digits (100 characters in five-unit code). The packing density is 250 bits per in (25·4 mm).

The information for the demonstration had previously been written at slow speed from punched paper tape through a photo-electric type of input reader. Equally, punched cards could be used, or the information could be written directly on the tape from a manually operated



The high-speed loop tape machine shown by Standard Telephones and Cables Ltd

keyboard, from a computer, or from an industrial telemetering device.

Mention must also be made of the 'Newport' tape machine—a magnetic tape recording instrument for handling teleprinter signals on a 'character start-stop' basis at normal telegraph speeds of up to 75 bauds; it may also be operated on a continuous basis up to 1000 bauds to obtain speed conversions for the rapid handling of traffic in telegraph and data processing systems.

The machine uses a continuous loop of oxide-coated sprocketed film, and an essential feature is that all signals are accurately positioned on the tape relative to the sprocket holes. Thus signals can be written on a start-stop basis at, for example, 50 bauds and read back at 1000 bauds on a continuous basis, or vice versa.

Finally, there was a pretty demonstration of bell-ringing, in which five bells were continuously rung according to the established rules of bell-ringing. This display was designed to show that there is a strange connexion between a number of problems being tackled on computers, although at first sight they may have nothing in common. The basic problem is that of finding all the possible routes for all the permutations of any given number of bells, and allied to this are many problems in other seemingly unconnected fields—for example, finding the best of all the possible routes for distributing and delivering goods. The study of problems of this kind was one of the factors in the development of the Theories of Symmetries and Groups, and a typical application of this theory is the study of crystals and the arrangements of atoms within crystals. This was illustrated by a demonstration of the calculation of angles and distances between atoms within a crystal.

The Scientific Symposium

The scientific symposium organized by the National Physical Laboratory and held at its premises at Teddington, Middlesex, was attended by over 200 delegates from many parts of the world. So great was the interest and the demand for seats that late applicants had to be regretfully turned away.

The largest overseas party came from the USA, which was represented by 22 delegates. The next largest contingents from abroad came from Switzerland and the USSR, with 7 delegates each, and other countries represented included Belgium, Czechoslovakia, France, Germany, Holland, Hungary, Israel, and Poland.

The purpose of the symposium was to bring together a body of international scientists whose fields of activity were covered by the following representative cross section of the papers read: character and pattern recognition; learning; language translation; biology; automatic programming; industrial planning, and clerical mechanization. Their discussions were on the broad field of how computers and other man-made machines can carry out processes which up to a few years ago were restricted to the human mind.

The complete texts of the papers, and a report of the discussions, will be published some time within the next few months by Her Majesty's Stationery Office. At the time of going to press with this issue, neither the publication date nor the price had been fixed.

The Business Symposium

This event was also filled to capacity at each session during its three days, and up to 800 delegates and visitors to the symposium, the exhibition, or both, came from 41 countries outside Great Britain.

Under the general heading of 'Computers as an Aid to Management', 23 papers were presented. These were listed in our last issue (November 1958, p 176), but a few changes had occurred since that issue went to press. In place of the two papers by K. F. Turner and L. Griffiths of Rolls-Royce Ltd, a paper was read by D. L. Rowlands of A. C. Nielson & Co Ltd on 'The Practical Application of a Small Commercial User', and a paper on 'A Practical Application in Commerce', by J. F. Body of Newton Chambers & Co Ltd, replaced the paper on 'A Practical Application in Mail Order Business', by P. Cotter and H. E. C. Nash (Littlewoods Mail Order Stores Ltd) and P. Shackleton (Elliott Bros (London) Ltd).

All the papers, with a report of the discussions, will be published shortly by Pitman Publishers, 39 Parker Street, London, WC2, at a price provisionally fixed at 75s.

Book Reviews

The Principles of Technical Electricity. *3rd edition. By M. Nelkon.* $8\frac{3}{4} \times 5\frac{1}{4}$ *in* (222 × 146 *mm*). *Pp* 250. *Illustrated. Index.* (*London: Blackie*, 1958.) Price 15s net.

The text of this edition of this well-known book uses the rationalized MKS system of units. In all other respects the text follows the pattern and does not differ greatly from that of the second edition reviewed in THE BEAMA JOURNAL of May 1956.

In writing the book, the author has had in view the needs of part-time students preparing for the subjects of Principles I and II of the telecommunication examination of the City and Guilds of London Institute. In consequence the topics are given a deliberately restricted treatment, but one adequate for the purpose of the examination.

Although the price has had to be increased, it is less than that of other books covering the same ground.

Although the author still uses obsolete terms such as 'condenser', the nomenclature, units, and abbreviations are mostly those now generally recognized as standard.

The book is well written and attractively printed and is well recommended for the preparation for the purpose of the Principles examination.

P. F. SOPER

Procedure for Obtaining Transient Response from Frequency Response. *By V. V. Solodovnikov, Yu. I. Topcheev, and G. V. Krutikova.* $9\frac{1}{2} \times 6\frac{1}{2}$ *in* (241 × 165 *mm*). *Pp* 193. *Illustrated. Index.* (*London: Infosearch*, 1958.) Price 42s net.

This book is an English translation of a Russian original of 1955, and will be of particular interest to engineers dealing with control system problems. The basic content comprises over a hundred pages of tables, and is supplemented by a description of the theoretical principles involved, by practical illustrative examples, and by relevant tables, curves, and nomographs.

The method for obtaining the transient response from the frequency response is essentially that of Floyd (Brown and Campbell, *Principles of Servomechanisms*, 1948), namely, the approximations of the real or imaginary frequency response curve by straight line segments, the separation of the piecewise linear frequency response curve into a number of trapezoidal frequency responses, and the evaluation of the transient response as the sum of the separate transients due to each trapezoidal frequency response. It is then shown that the transient response due to each trapezoidal frequency response can be obtained in terms of the transient response due to a unit trapezoidal frequency response, defined as unity from zero up to a frequency of k, zero for frequencies greater than unity, and decreasing linearly from a frequency of k up to a frequency of unity. A four-decimal table of this basic transient response is given for time $t = 0{\cdot}0\ (0{\cdot}2)\ 50{\cdot}0$ for each $k = 0{\cdot}00\ (0{\cdot}01)\ 1{\cdot}00$, and occupies over half of the book. The use of this table will substantially reduce the amount of calculation necessary for the evaluation of the transient response by this method.

The tables are preceded by a brief outline of the theoretical principles and essence of the method of derivation of transient responses of dynamic systems in general, and in particular of automatic control systems, from their frequency responses. In addition, the book contains certain auxiliary graphs and nomographs facilitating the plotting of frequency responses prior to the derivation of transient responses. (In this connexion Nyquist plots, M-contours, Nichols charts, etc., are known only by their functional names in Russian, and these have been used throughout this text.) Finally, there is a chapter illustrating the use of the frequency response method in the solution of real problems from various branches of engineering. These practical examples include a servo system under the effect of a relatively complex disturbance, an automatic control system with time lag, and a system with distributed parameters.

This book is of interest not only for its content, but also for its method of presentation. When function tables are published in this country or in America, the usual practice appears to be to precede them by a description that is the bare minimum necessary for their efficient use. This process often leads to much time spent in the consultation of other relevant publications. The authors of the present work are to be especially congratulated on a most sensible and painstaking achievement in the combination of the tables with relevant theory, examples, and nomographs, permitting their ready use.

H. GOLDENBERG

Applied Mathematics for Engineers and Physicists. *2nd edition. By Louis A. Pipes.* $9\frac{1}{4} \times 6\frac{1}{4}$ *in* (235 × 159 *mm*). *Pp xi* + 723. *Illustrated. Index.* (*London: McGraw-Hill*, 1958.) Price 68s net.

This book was first published in 1946 and we gave it a long review in our issue of December 1947. The new edition contains over a hundred more pages and is of better quality production than its predecessor which, unavoidably, suffered as a result of immediate post-war conditions—although by no means badly. There is the same number of chapters, the titles of which are nearly identical with those in the earlier edition. However, the new one contains much new subject matter while the original text has now substantially been revised in order to take account of subsequent practical developments and usages.

Additional material on the inversion of large matrices has been included and an entire section on matrix algebra has been rewritten. New material on the computation of eigenvalues of matrices has been added together with their applications to problems in dynamics. A more thorough treatment has been accorded to the Laplace transform and its applications, and an entirely new section has been added on tensor analysis.

The section on the calculus of variations and its applications has been completely rewritten. The chapter dealing with non-linear oscillatory systems has been expanded to include an account of modern developments in the solution of non-linear differential equations. The chapter on wave equations now includes applications to acoustics and to electromagnetic wave propagation. Other new matter includes a discussion of non-conservative dynamical systems, a section on the solution of linear integral equations using transform methods, a treatment of acoustical vibrations and electromagnetic waves, and additional studies in the analysis of electric circuit problems. The book contains examples and problems as before, the number of the latter being nearly doubled.

Revision of a book, if not a thankless task, is not altogether an enviable one. It is so easy to add to or change the text in one place and overlook the repercussions such modifications may have elsewhere, unless one is meticulously careful. We have not found any evidence of such oversights in the present work and the author is to be commended for his very sound craftsmanship.

The scope of the book is considerable and, broadly speaking, it provides the mathematical techniques for the solution of problems arising in the analysis of linear and non-linear lumped and distributed systems under the influence of both steady-state and transient forces. That it is written by a professor of engineering should be an added attraction to engineers and physicists, to whom we thoroughly recommend it.

S. AUSTEN STIGANT

Theory of Electrical Machines. *By W. S. Wood.* $10 \times 6\frac{1}{4}$ *in* (254 × 159 *mm*). *Pp x* + 317. *Illustrated. Index.* (*London: Butterworths Scientific Publications*, 1958.) Price 50s net.

This new book on the theory of electrical machines is intended to provide a complete text to a study of electrical machines suitable for the needs of final year undergraduate students of electrical engineering. In an attempt to achieve this aim, the author has endeavoured to generalize the subject without extensive departure from conventional methods of presenting the theoretical principles.

In the preface the author states that, since the book is intended for undergraduate use, little attention has been given to purely constructional details or to design problems. An appendix is included to cater for those students who are interested in the fundamental principles of design. Although these design concepts are not normally included in a modern course on electrical machines, the author considers that such knowledge contributes to a general understanding of the principles of operation of electrical machines.

In this book the author generalizes the treatment of both armature windings and the action of commutators, so that the application to either ac or dc machines is then merely a special case. This generalization is essential if all students of electrical engineering are to receive a broad and basic understanding of the whole field of electrical

engineering endeavour. Since all too many students qualify as narrow specialists, any book which attempts to generalize any part of a subject of the course is a welcome addition to undergraduate textbooks.

It is well known how difficult it is to determine how far industrially immature students can be taken in any branch of knowledge during the undergraduate course. Only experience will show whether all the material gathered together in this book can be dealt with in a general electrical engineering degree course. The need to give more electrical engineering students the general type of course in preference to the specialized variety is now becoming recognized. In consequence there will be an increasing demand for books with this broad general outlook.

The book is well written in a clear and attractive style, and although many of the diagrams are small they are readable and well labelled. It is well recommended and should be on the shelves of the technical section of all libraries.

P. F. SOPER

An Introduction to the Theory and Practice of Semiconductors. *By A. A. Shepherd.* $7\frac{3}{4} \times 5\frac{1}{4}$ *in* (197 × 133 *mm*). *Pp* 206. *Illustrated. Index.* (*London: Constable*, 1958.) Price 18s 6d net.

This book well achieves what is set out in the title, and the author has made a sound choice of what is essential for beginners in the large field of semiconductors. Structure of solids, conduction in semiconductors, the properties of single crystals, semiconductor rectification, and transistors are all dealt with. As one might expect, germanium and silicon devices are dealt with in the most detail.

The publisher's note on the book states that it has been written for advanced students and graduates in all fields of physics, but it can also be recommended to electrical engineers who are newcomers to modern semiconductor devices, and who feel that they should know some of the basic physics that lie behind them.

J. H. J.

Handbook of Microwave Measurements. 2 *Vols. Edited by Moe Wind and Harold Rapaport.* 11 × $8\frac{1}{2}$ *in* (279 × 216 *mm*). (*New York and London: Interscience Publishers*, 1958.) Price 96s net.

Handbook of Electronic Measurements. 2 *Vols. Edited by Moe Wind.* 11 × $8\frac{1}{2}$ *in* (279 × 216 *mm*). (*New York and London: Interscience Publishers*, 1958.) Price 120s net.

These books are of the kind to which we can imagine Lord Kelvin would have accorded high approval had they been available in his day, for they deal so very thoroughly with both the theory and practice of measurements in the stated fields and succeed in welding the two together in a manner which can hardly fail to be satisfactory to theoretician and practitioner alike.

The broad plans of the two works are similar, each being divided into a number of major chapters relating to a particular characteristic quantity. These chapters are each the work of individual specialist authors and there is a pleasing uniformity of style and treatment throughout the books that speaks well for the editorial labours and the co-operation of the authors.

The microwave handbook was first published in 1954 and the present edition contains extended reference matter as well as incorporating corrections and revisions. The larger volume comprises the written text whilst the smaller one contains only the illustrations referred to in the former. The object of this is to enable the reader to view text and illustrations simultaneously.

The 20 sections of the book deal with measurement of the following: frequency and wavelength, standing wave ratio, attenuation, power, the Q factor, impedance, power voltage breakdown, propagation function, dielectric constant, radio frequency leakage, directional couplers, receiver characteristics, klystron characteristics, magnetron characteristics, duplexing tube characteristics, and antenna; there are other sections devoted to spectrum analysis, hybrid junctions, noise generation, and crystal characteristics. Appendices deal with the use of the Smith chart, Rieke diagram, transmission line charts, and impedance matching techniques. A bibliography for further reading is given at the end of each section.

Measurement methods and techniques are given in each section in considerable detail and illustrative examples are included where this can be done. There is also a substantial content of associated theory, equipment description, and discussion of accuracies in each section.

The electronic handbook is an entirely new publication consisting of 18 chapters, of which the first 5 are contained in Vol I and the remaining 13 in Vol II.

Chapter 1 is introductory and deals with electromagnetic fundamentals. Chapters 2 to 8 inclusive relate to the measurement of fundamental parameters as follows: voltage and current, power, impedance, frequency and wavelength, time interval, phase, and field intensity and radiation. Chapters 9 to 18 inclusive describe precise techniques for the measurement of the characteristics of electronic devices, each giving in detail the better known and more readily applicable procedures relating to the particular quantity under consideration. More specifically they cover bandwidth, gain, noise figure, transient response, distortion, oscillographic observation of waveforms, stability, modulation, spectrum analysis, and attenuation. A bibliography of books and papers is appended to each chapter, some of them being most comprehensive.

Complete descriptions and illustrations of necessary equipment are given throughout the volumes, and accuracies and physical magnitudes are indicated. Where necessary, extended theoretical treatments are given to supplement the descriptions of measurement techniques employed.

These books all bring together a mass of highly important information on their respective subjects and they should be really invaluable to all those whose work is connected in any way with measurements in the microwave and electronic fields. The books are lithoprinted in first-class style—but what a pity they are not uniform in size with the symposia volumes published by the Microwave Research Institute.

S. AUSTEN STIGANT

Basic Electrical Engineering. *By J. Shepherd, A. H. Morton, and L. F. Spence.* $8\frac{1}{4} \times 5\frac{3}{4}$ *in* (222 × 156 *mm*). *Pp viii* + 310. *Index.* (*Sir Isaac Pitman & Sons*, 1958.) Price 27s 6d net.

This new book on basic electrical engineering technology is intended to provide for the needs of students following the Ordinary National Certificate course in electrical engineering. To some extent it also covers the requirements for much of the syllabus in applied electricity in the Part I BSc(Eng) examination of the University of London.

The text of nine chapters, based on the rationalized MKS system of units, discusses successively units and simple circuits, elements of electromagnetism, elementary instruments and measurements, capacitors and electrostatics, single-phase and simple three-phase circuits, the direct-current machine, transformers and elementary electronics.

The treatment of the subject matter follows closely the pattern now generally recognized as appropriate for this type of course. Although the authors start from first principles it is not clear whether the student is in fact expected to have had a prior grounding in electricity and magnetism. If not, the development of the subject would probably be too fast for the average student.

The authors have taken care to use standard symbols, abbreviations, and nomenclature throughout the book, which is illustrated with 220 line diagrams. It is worth recording that where circuit diagrams incorporate machines, these diagrams show the field coils in their correct position relative to the armature and brushes.

Since this is essentially a well-written textbook intended for students preparing for an examination, the text incorporates 79 fully worked examples. At the end of each chapter there are a number of problems—in all 112—by which the reader may test the knowledge he has acquired from the book. Answers have been wisely given to each numerical problem to help the lone reader.

In any future edition the authors should ensure that all the phasor or complexor diagrams are drawn with the reference phasor or complexor horizontal. Obsolete terms like 'dynamometer-type instrument' should be deleted.

P. F. SOPER

Reflex Klystrons. *By J. J. Hamilton.* $8\frac{1}{4} \times 5\frac{3}{4}$ *in* (222 × 146 *mm*). *Pp xi* + 260. *Illustrated. Index.* (*London: Chapman & Hall*, 1958.) Price 45s net.

Although the reflex klystron was about the first microwave valve to be manufactured on a comparatively large scale, it still has an important place in the range of ultra-short-wave valves available to the radio design engineer. A book devoted to it is a worthwhile effort, and the present volume is an excellent achievement. It succeeds in summarizing the vast amount of work that has been done on these valves, and presents it in a very readable form for the radio engineer and the student. Some mathematical treatment is of course essential for a full explanation of klystrons, but the amount of mathematics has been kept to a minimum.

Chapters are devoted to cavity resonators

and output systems, the electron dynamics of the valve, load effects, manufacturing aspects, a survey of orthodox and unorthodox klystrons, and in conclusion there is a brief note on future trends.

Probably few readers will use the chapter on the engineering and manufacturing aspects of the reflex klystron, but the author is to be commended on including such information. It is always to the good that users of a device should have some detailed knowledge of the care and difficulties associated with its manufacture.

J. H. J.

Electronic Digital Computers: Their Use in Science and Engineering. *By Franz L. Alt. 9¼ × 6¼ in (235 × 159 mm). Pp x + 336. Illustrated. Index. (New York: Academic Press,* 1958.) Price $10·00 net.

This book is addressed primarily to the *users* of computers, although there is matter in it that is of interest to the problem analyst and to the design engineer. It is intended to form an introduction to the field of electronic computers. That is to say, the objective is to provide the reader with such information as is needed to talk intelligently to the computer specialists with whom he may have to deal.

The work is in five parts which are, respectively, an introduction covering objectives, machines, programming and coding, and problem analysis; automatic digital computers, giving an historical survey, functions and components, number representation, memory, arithmetic, control, and input and output; coding and programming; problem analysis; and matching problems and machines.

Descriptions of machines deal mostly with their functioning. Programming and coding mainly give an explanation of terms used by the expert. Problem analysis lists commonly used methods and evaluates the advantages and drawbacks of different methods from the standpoint of automatic computation. In the final part a number of computer applications are given from the principal fields in which computers have been used. Machine characteristics required for their solution are indicated, and the criteria are stated by which the originator of a problem may judge the suitability of a particular machine for his problem.

An extensive bibliography is provided, and there is an excellent subject index.

Users of electronic computers will find this book both interesting and of value, and a thoughtful reading of it will well repay the time spent thereon.

S. AUSTEN STIGANT

Electrical Maintenance and Repairs. *By J. L. Watts. 7½ × 5 in (191 × 127 mm). Pp* 324. *Illustrated. Index. (London: Cleaver-Hume,* 1958.) Price 21s net.

The author has crammed into this pocket-sized volume the results of what must have been an extensive experience in every sort of fault-finding and repair. It should undoubtedly be available to all factory electrical engineers and electricians, because the author's approach is the sensible one of suggesting the types of fault that might appear, and then indicating the basic approaches to remedy or repair the trouble, rather than giving large numbers of specific examples.

He deals with routine inspection and maintenance of wiring installations, protective gear, control gear, and the like, and then turns to fault location on the installation and on the plant itself. Occasionally it might be thought that his eagerness to give as much information as possible tends to a slightly superficial approach. But if the book is regarded not only as a very present help in time of trouble, to be seized and taken out to the site of the fault, but as a volume to be read carefully in leisure moments so that principles are clearly established in the reader's mind, then its full value will become apparent. It can be recommended without reserve.

J. H. M. S.

Programming for an Automatic Digital Computer. *By K. H. V. Booth. 8¾ × 5½ in (222 × 140 mm). Pp vii + 238. Index. (London: Butterworths Scientific Publications,* 1958.) Price 42s net.

There is at Birkbeck College, London, an All Purpose Electronic X-ray Calculator—APEXC—which was built primarily for simplicity of operation rather than speed, and as a result it contains only 15 orders. It is thus an easy machine on which to use the basic ideas and techniques of programming, and the present book describes these in considerable and precise detail.

The machine consists of four components: the arithmetic unit, the control, the memory or store, and the input-output equipment. These are described in the first chapter along with the system of coding and form of orders. The technique of programming is next dealt with in the subdivisions: the schematic programme and the detailed programme. Input and output in both decimal and binary forms are then discussed, schematic and detailed programmes being given for both.

The next five chapters are, respectively, on division and square root, miscellaneous sub-routines, non-arithmetic programmes, matrix operations, and simultaneous linear equations, schematic and detailed programmes again being given throughout. Mechanical translation is then dealt with, a typical programme being given for a French to English translation. The remaining three chapters describe an interpretive programme for decimal tapes, interpretive routines and pseudo-codes, and fault finding and automatic programming, respectively.

A book such as this has been badly needed for some time and the author has rendered a considerable service to the users of computers in writing it. She says '. . . it has been our experience that it is possible to train people to do useful programming in a matter of two weeks, although the acquiring of the more subtle tricks of the trade naturally takes longer'. This book should go a long way towards preparing the would-be programmer for his or her new venture and promoting a more speedy understanding of the technique required. The book is well printed and produced.

Atomic Terminology. *By Lore Lettenmeyer. 7 × 4½ in (180 × 115 mm). Pp* 298. (*München: Isar Verlag,* 1958.)

This useful little volume provides in four languages—English, German, French, and Italian—a selection of the essential scientific and technical terms in general use in nuclear physics, reactor engineering, and associated fields.

It covers 1814 terms, listed alphabetically in English, which is used as the key, since this is the language in which most of the literature is published. Each term is numbered consecutively, and the German, French, and Italian equivalents are given in parallel columns with the same consecutive numbers. Following the main four-language section are separate alphabetical German, French, and Italian indexes with the terms numbered to correspond with the main section, so that the translation of any term in any of the four languages can be found easily and quickly.

No attempt is made to define the terms, but where a particular concept can be expressed in English by several terms, these are given in their alphabetical order, with adequate cross references in the other languages.

Chambers's Technical Dictionary. *Edited by C. F. Tweney and L. E. C. Hughes. 8½ × 5½* in (216 × 140 mm). *Pp* 1028. (*London: W. & R. Chambers,* 1958.) Price 35s net.

Now in its third edition, this technical dictionary, which was first published in 1940, has become a valuable reference work in science and industry. The aim of the compilers is to give definitions of terms that are of importance in pure and applied science, in all branches of engineering and construction, and in the larger manufacturing industries and skilled trades. In order that the dictionary should be as complete and as accurate as possible, specialists in each of the fields covered have been fully consulted. In electrical engineering the contributors include H. Rissik, Dr A. T. Starr, and E. O. Taylor, all well known for their books and articles in the technical press.

While the original text has been considerably revised, most of the later additions have been included in a 74-page supplement; this seems a pity, as it often means looking for a reference in both the main section and the supplement. Terms that have now been in general use for some time, such as induction heating, transistors, thermistors, which are included in the supplement, might well have been incorporated as part of the revision of the main text of the book, and the supplement used for only late entries. There are also included some useful tables covering chemical elements, igneous and sedimentary rocks, and the vegetable and animal kingdoms.

The dictionary, except for the points noted above, is very comprehensive, well compiled, and the definitions of terms are very clear and concise. This is a book which should prove most useful on the bookshelf of all who are in any way concerned with the technical side of industry.

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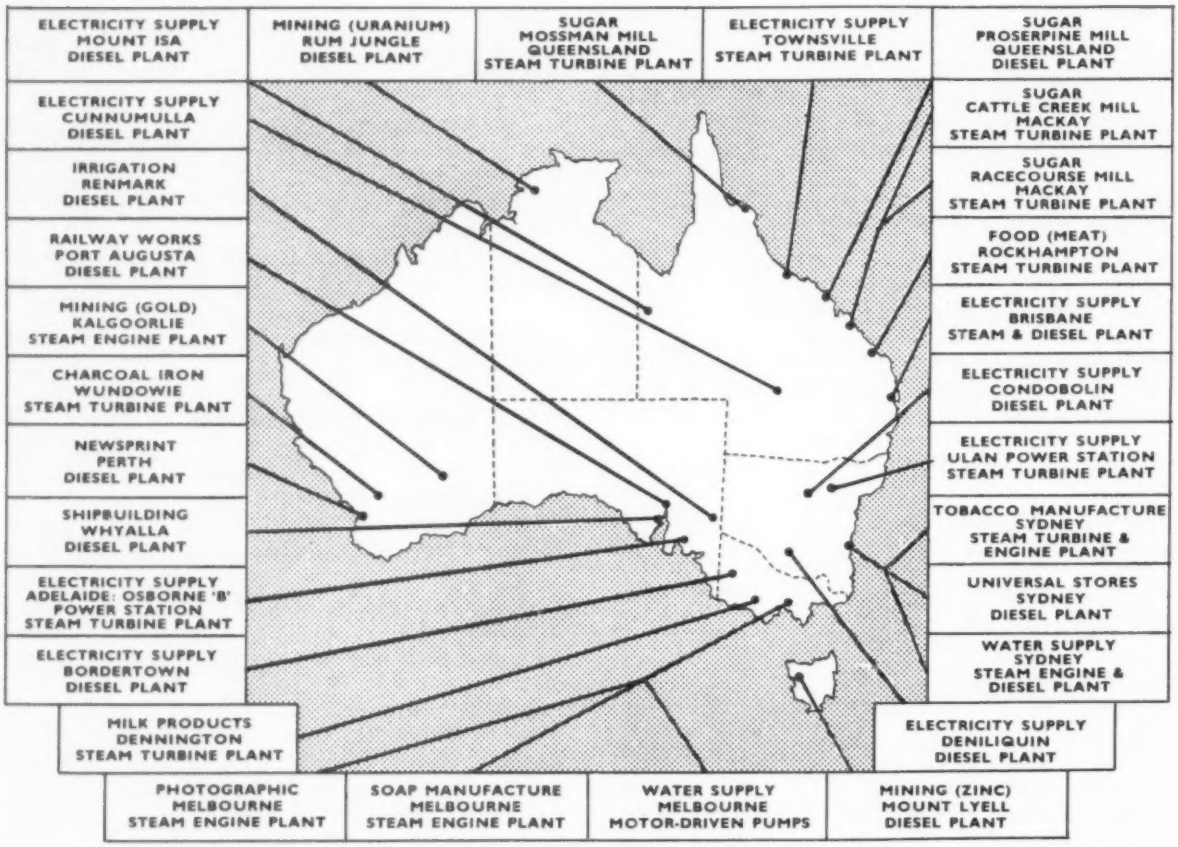
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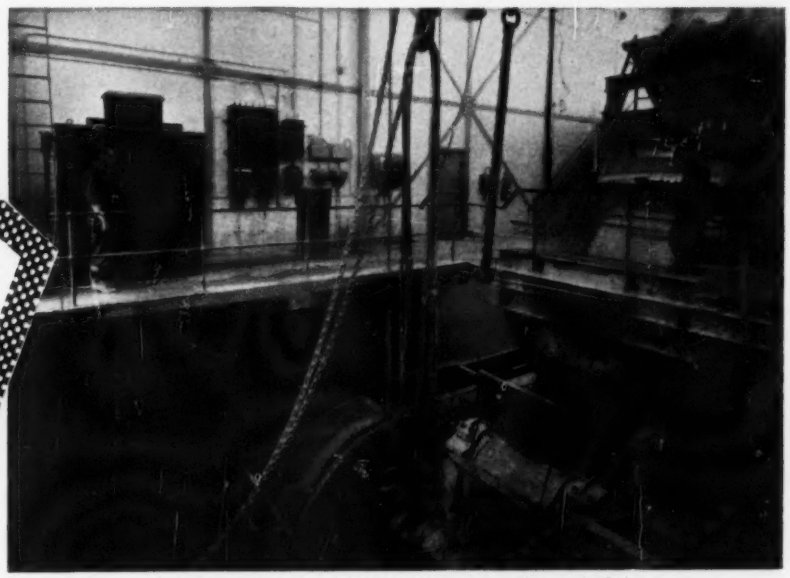

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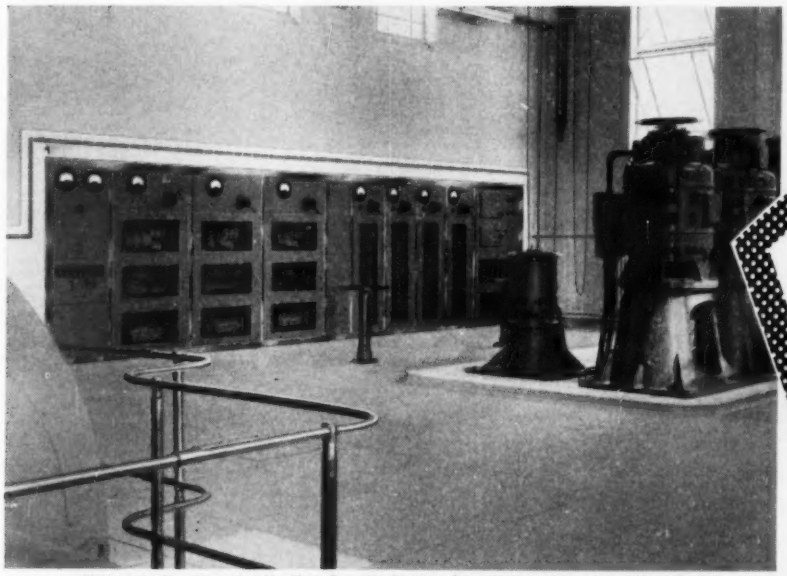

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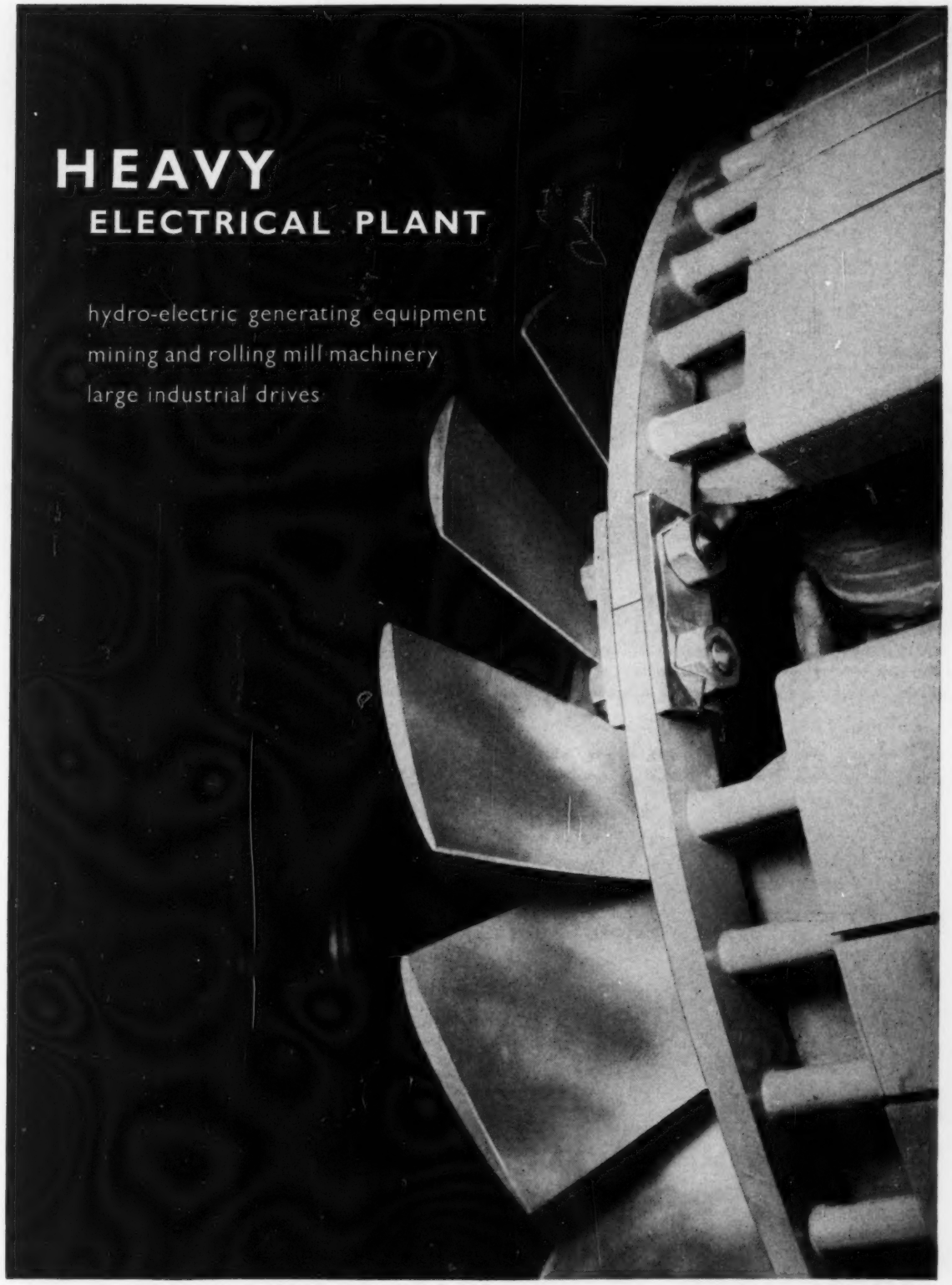

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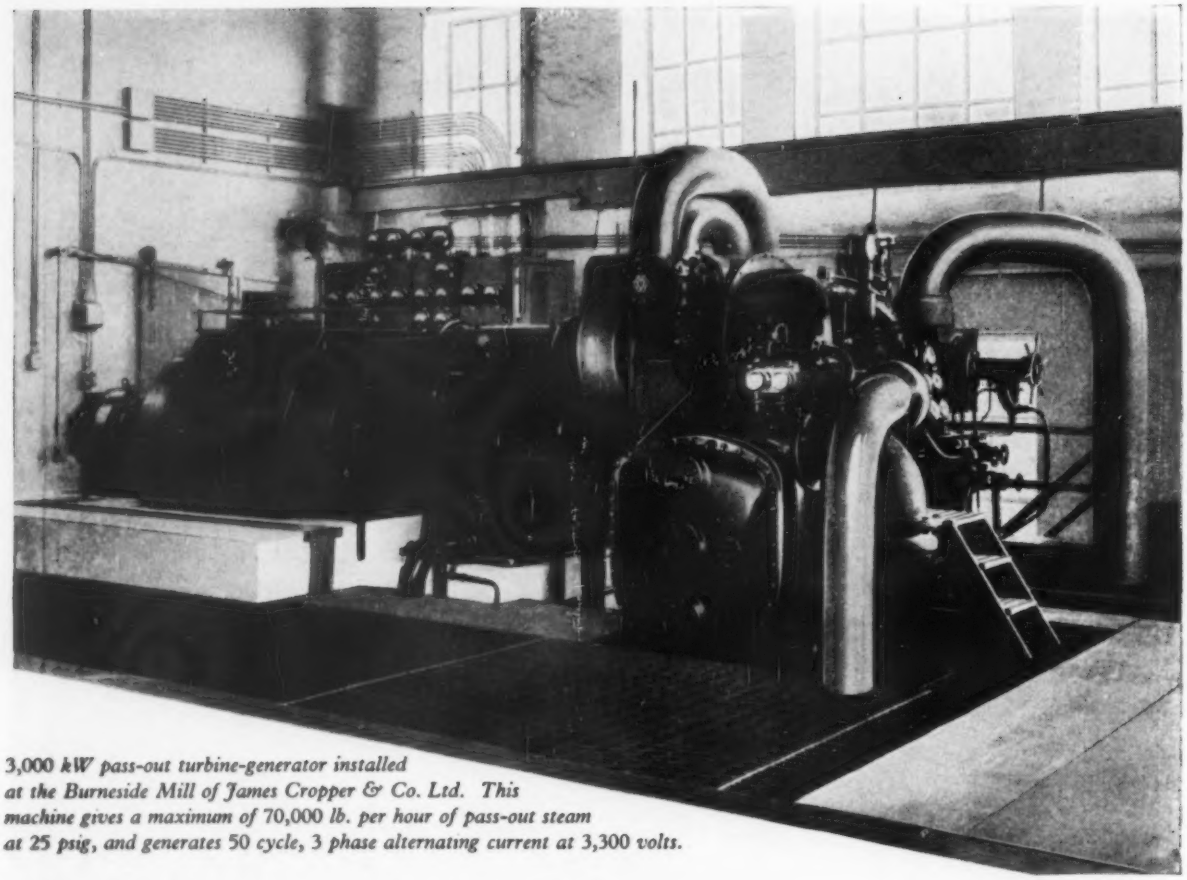

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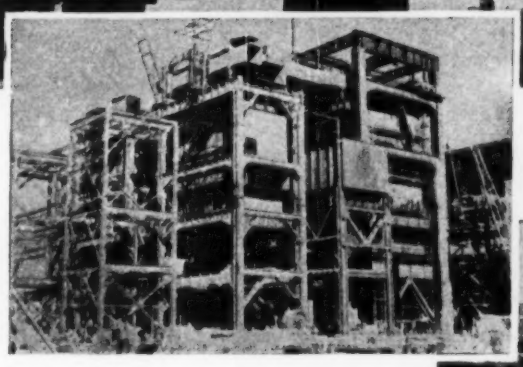

Above and left: Boiler plant during erection at the Mercer power station.

Below: Aerial view of the site on the Waikato river. Fuel will be supplied from the nearby Maramarua coalfield.

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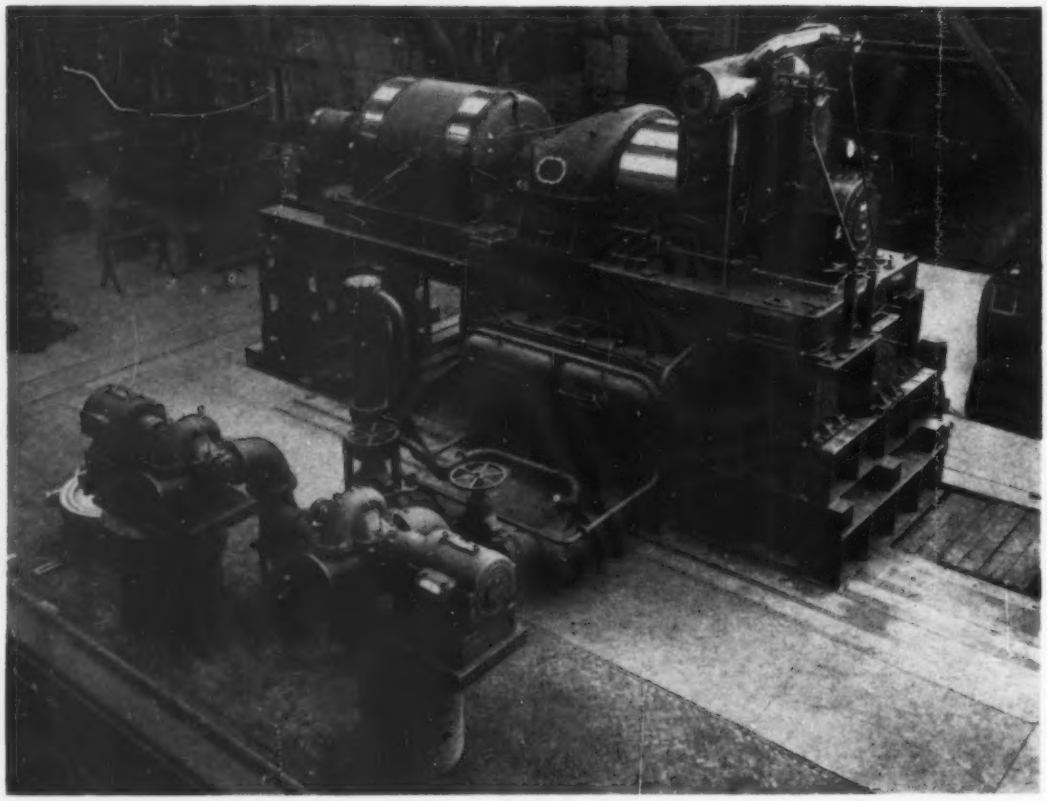

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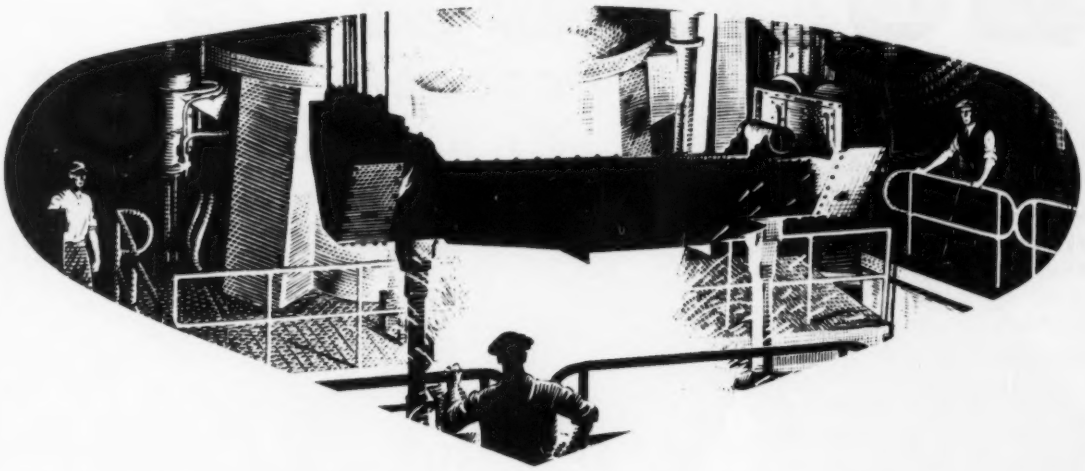

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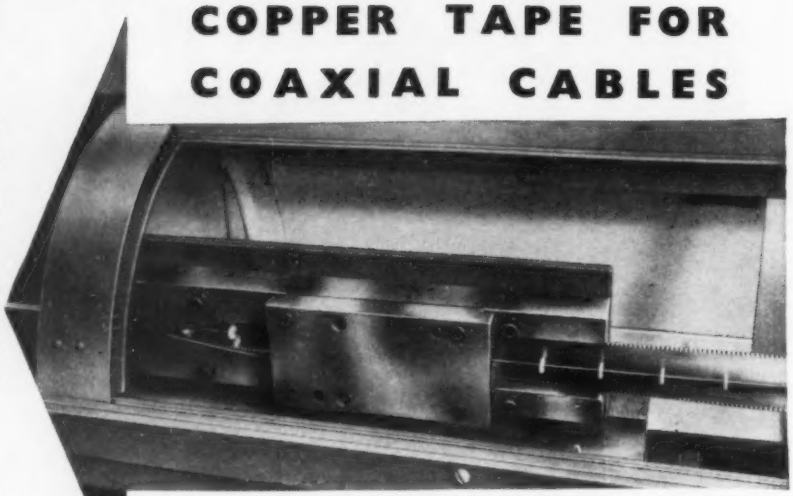

The photograph shows the flat copper tape after edge treatment being fed into the forming die to form the outer conductor of the coaxial tube.

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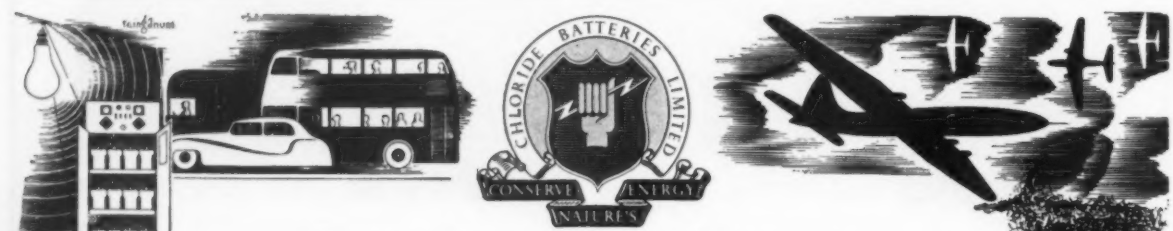

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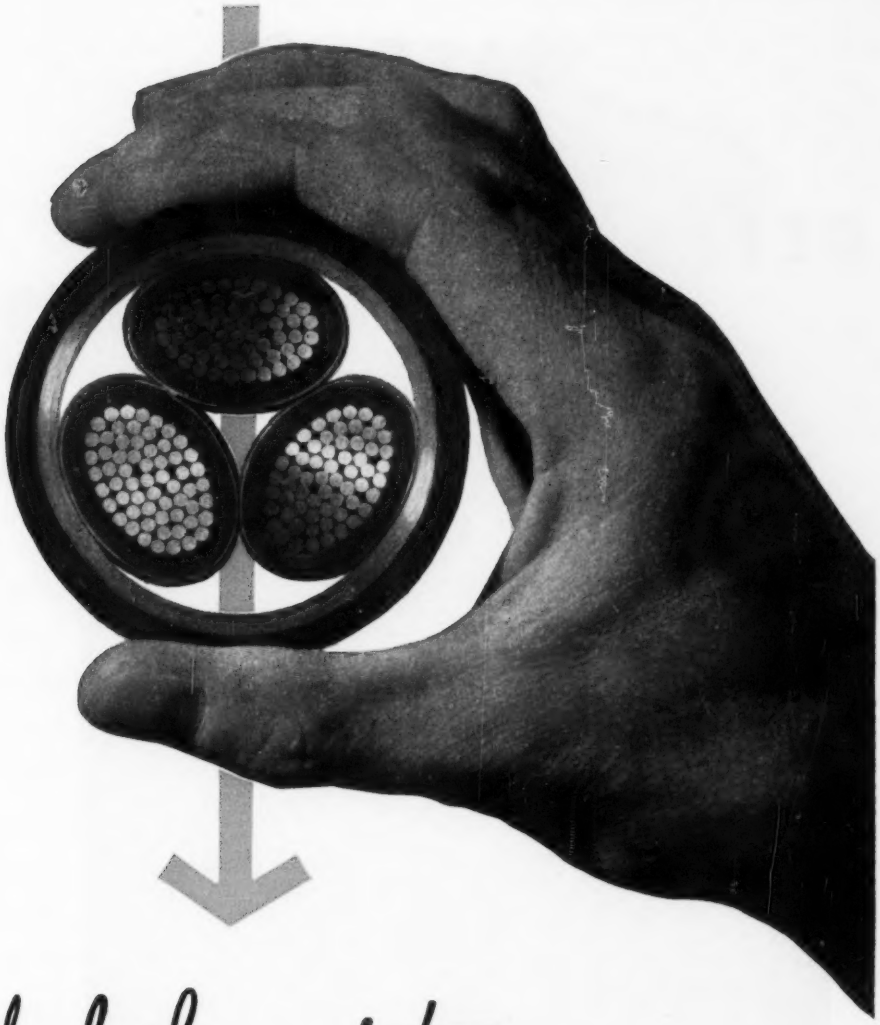

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The D.S.O. oil-filled cable is our latest development in 33kV power transmission.

Dispensing with fillers and built-in ducts, the design means economy in materials and manufacture.

Publication No. 392 giving further information is available on request.

BICC **DSO** *DUCTLESS SHAPED-CONDUCTOR OIL-FILLED*

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SAFE DEPENDABLE CONTROL

FOR GROUPED MOTOR CONTROL the safe, dependable choice is a CHESTER MAJOR switchboard.

Consider these features—short circuit protection up to 35 MVA; all isolating swing-out or draw-out starting panels; every component tested in excess of BS specifications. Then add—backed by 60 years' experience; fully tooled; short delivery.

In every respect it will pay you to switch to the CHESTER MAJOR.

Illustrated is a CHESTER MAJOR switchboard supplied for controlling the materials handling system in a tin mine in Tanganyika. Extreme accessibility with complete isolation permits safe, simple maintenance by unskilled native labour.

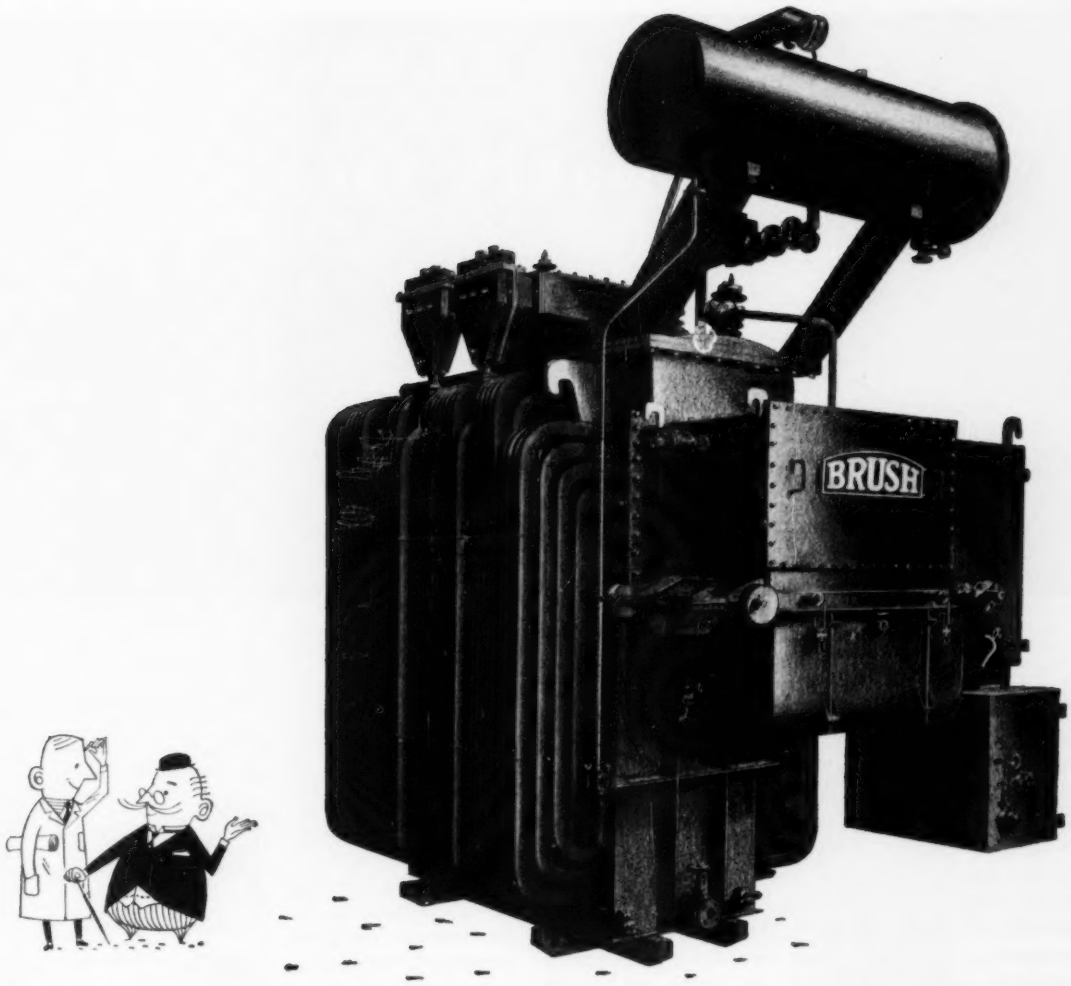
BROOKHIRST

CHESTER MAJOR SWITCHBOARD

BROOKHIRST SWITCHGEAR LIMITED NORTHGATE WORKS CHESTER

A METAL INDUSTRIES GROUP COMPANY

cvs-61



Why must we have a Brush transformer?

Oh, well Sir, you see . . . Well, there's so much one can say . . .

All right then, say it man. Why Brush?

Well Sir, first of all I'd like to remind you that Brush built their first transformer as long ago as 1880, and . . .

Here! Wait a minute. We're not buying for historical reasons are we?

Of course not Sir, but it's worth remembering that this early transformer was an absolute innovation as far as dependability is concerned, and set a standard for quality that Brush have maintained ever since.

I see. You mean it's Brush experience plus quality that pays in the long run, eh?

I do indeed Sir. After all, it's not by accident that Brush transformers are giving such trouble-free service in every part of the world. And another thing. Think of the meticulous research and thorough tests which must have gone into this high-speed resistor-type tap changing gear we're considering, to say nothing of . . .

All right, I see your point.

You mean Sir, that we can get in touch with Brush?

Of course. What are you waiting for?

BRUSH
the power people

For further information on Brush transformers and tap changing gear, write to:
BRUSH ELECTRICAL ENGINEERING CO LTD · LOUGHBOROUGH
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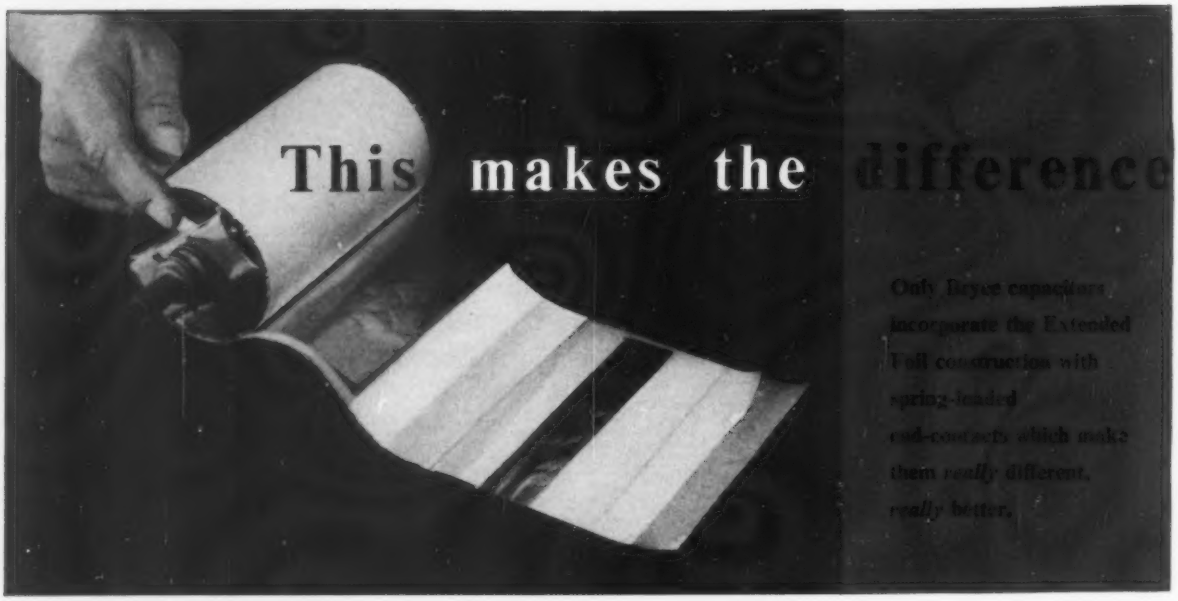
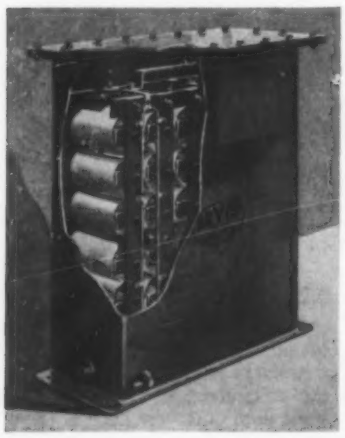
Z2


This makes the difference
Only Bryce capacitors incorporate the Extended Foil construction with spring-loaded end-contacts which make them really different, really better.

Four Contacts per Turn.

The foil in these Bryce capacitors is extended beyond the edge of the impregnated paper dielectric to right and left alternately, and the unique spring-loaded end-contacts provide four conducting paths on each turn of foil, giving better electrical and thermal conduction, and an almost completely non-inductive winding.

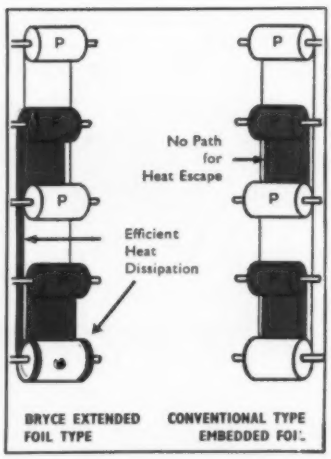
The importance of minimal heat production and improved dissipation requires no emphasis, since it is within the experience of all Electrical Engineers that heat is probably the commonest cause of capacitor breakdown. The Bryce Extended Foil capacitor element holds down temperature rise because there is improved heat transfer from dielectric to case side-walls and less heat generated due to resistance losses.



No Processed Joints.

The spring-loaded pressure contacts at each end of the capacitor element supersede the conventional method of inserting a connection strip in the capacitor element during winding.

With this arrangement the strip only makes contact over a small area of foil, and the length of the current path is great, with consequent resistive and inductive losses. Also this method is known to tend to give rise to internal discharges. The method of using a soldered connection from the foils, while overcoming these disadvantages, introduces the risk of damaging the paper dielectric by overheating.



Short Current Path.

The current path is the most direct conceivable and the multiplicity of contact points provides insurance against faulty connection, even under the most severe surge conditions. Improved efficiency of the conducting path minimizes current densities and consequently keeps to a minimum the temperature rise due to this cause.

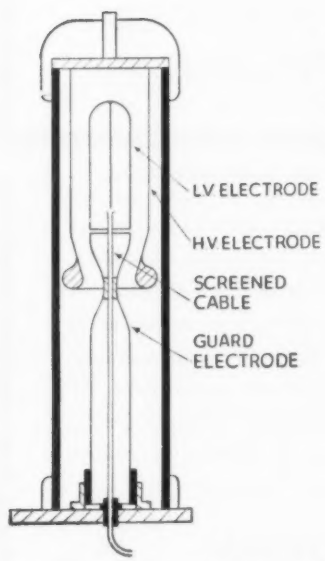
Better Heat Dissipation.

With projecting foils there is a high conduction path for heat from the centre of the element to the oil or Aroclor which is used as a coolant. The heat conductivity is much better than that with embedded foils where heat has to be conducted through paper which is a very poor heat conductor. The lower temperature gradient in Bryce Capacitors improves their expectation of life.

BRYCE
BRYCE ELECTRIC CONSTRUCTION CO. LTD.
Kelvin Works, Hackbridge, Surrey Telephone: Wallington 2601
In association with Hackbridge Cable Co. Ltd.

Broadway/bec 7

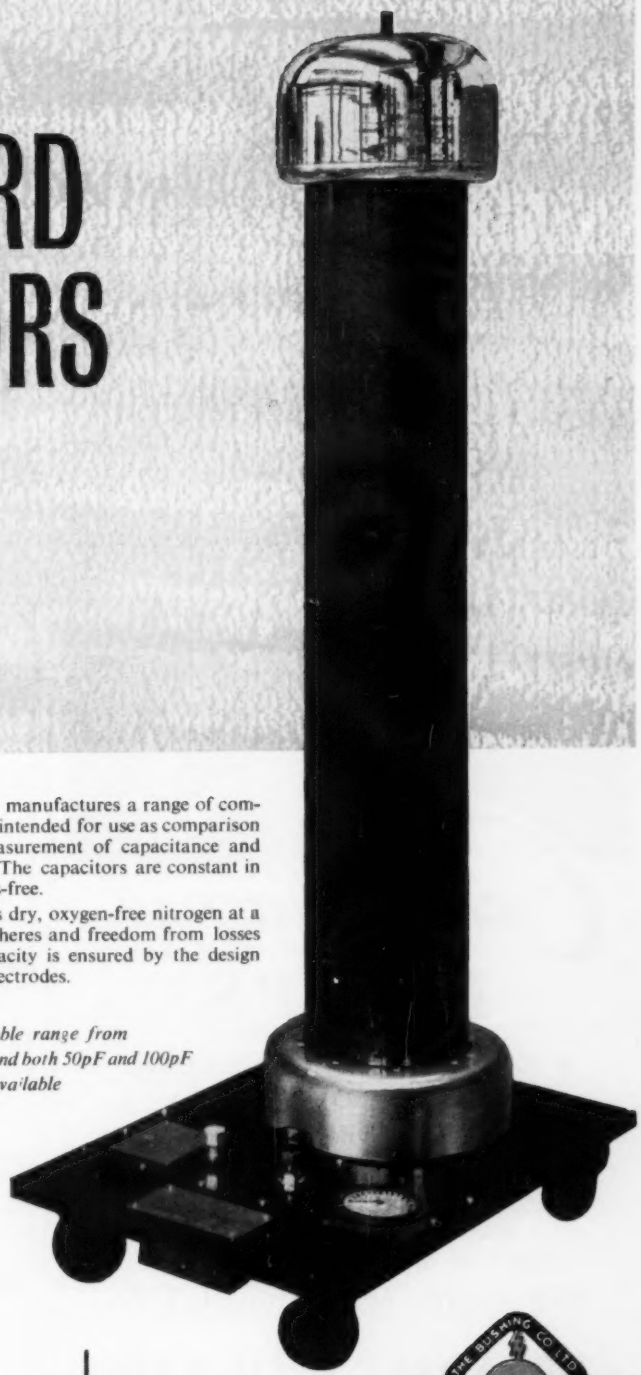
STANDARD CAPACITORS



The Bushing Co. Ltd. manufactures a range of compressed gas capacitors intended for use as comparison standards for the measurement of capacitance and dielectric loss factor. The capacitors are constant in value and virtually loss-free.

The gaseous insulant is dry, oxygen-free nitrogen at a pressure of 10 atmospheres and freedom from losses and invariance of capacity is ensured by the design and screening of the electrodes.

The sizes available range from 50k V to 500k V and both 50pF and 100pF capacitors are available in each size.



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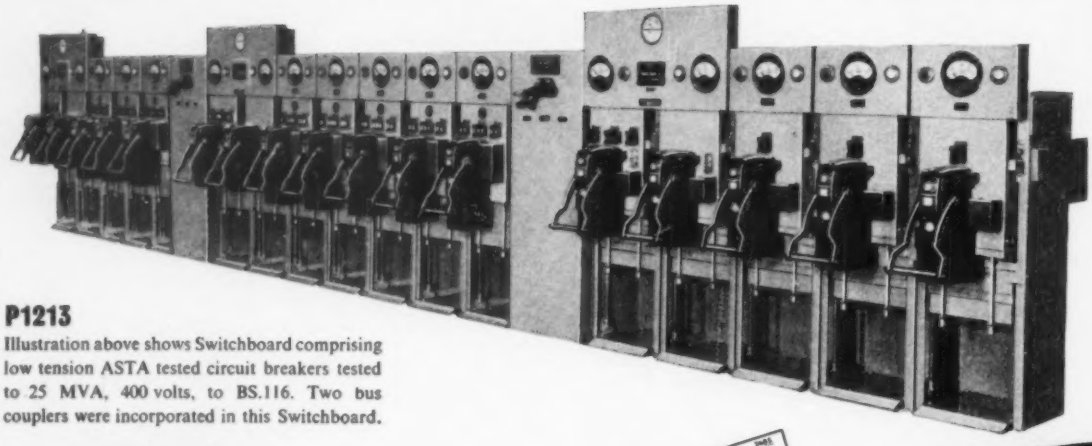
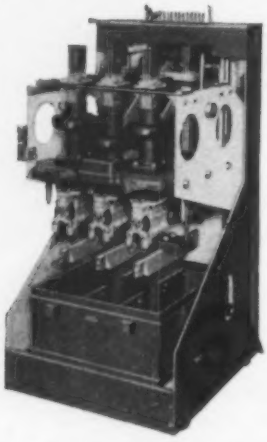
FOR HEAVY DUTY

THE MB RANGE OF CIRCUIT BREAKERS ILLUSTRATED BELOW HAS BEEN SHORT CIRCUIT TESTED AT AN ASTA STATION, THE LOW TENSION RANGE HAVING A CERTIFICATE FOR 25MVA, 400 VOLTS. THE 3·3 KV RANGE 75 MVA, ALL TO BS. 116.

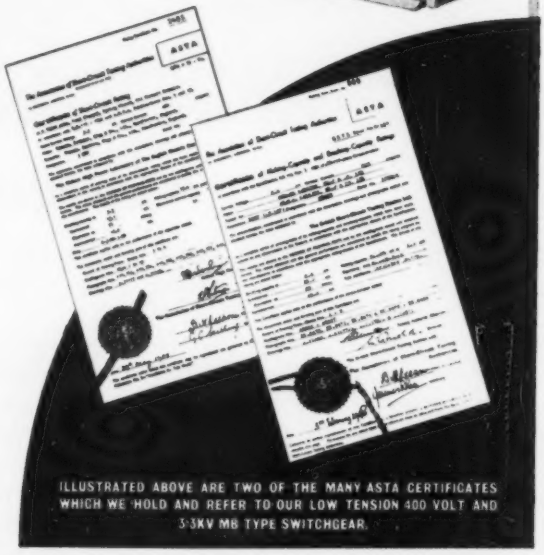


P1213
Illustration above shows Switchboard comprising low tension ASTA tested circuit breakers tested to 25 MVA, 400 volts, to BS.116. Two bus couplers were incorporated in this Switchboard.



P1245 The circuit breaker unit illustrated at the left is one of our 1600 amp. units of the same range as illustrated in the Switchboard above. It is of modern robust construction and suitable for controlling a 1000 kVA transformer.

May we have your enquiries?



ILLUSTRATED ABOVE ARE TWO OF THE MANY ASTA CERTIFICATES WHICH WE HOLD AND REFER TO OUR LOW TENSION 400 VOLT AND 3·3KV MB TYPE SWITCHGEAR.

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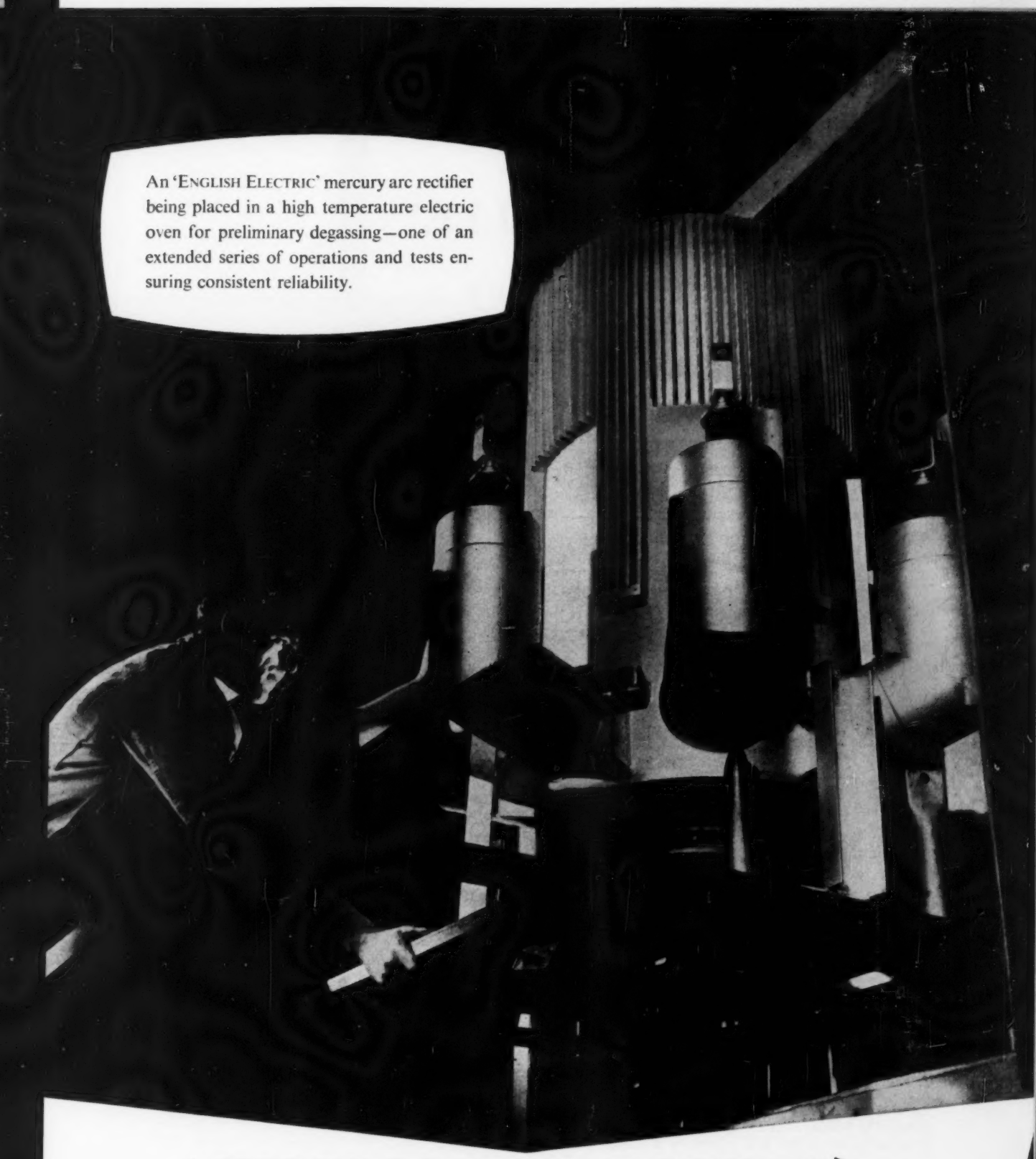

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P.74

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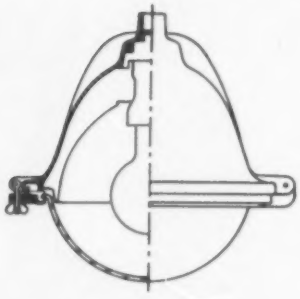
WEATHERPROOF, VAPOUR, DUST AND CORROSION RESISTANT

For use with 300 watt and 500 watt Tungsten filament lamps or 250 watt and 400 watt type MBF/U lamps



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SPECIFICATIONS OF R.96720 "GRENVILLE" UNIT

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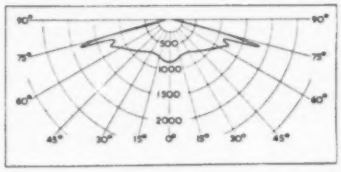
All external bolts, nuts and fixings are of stainless steel.



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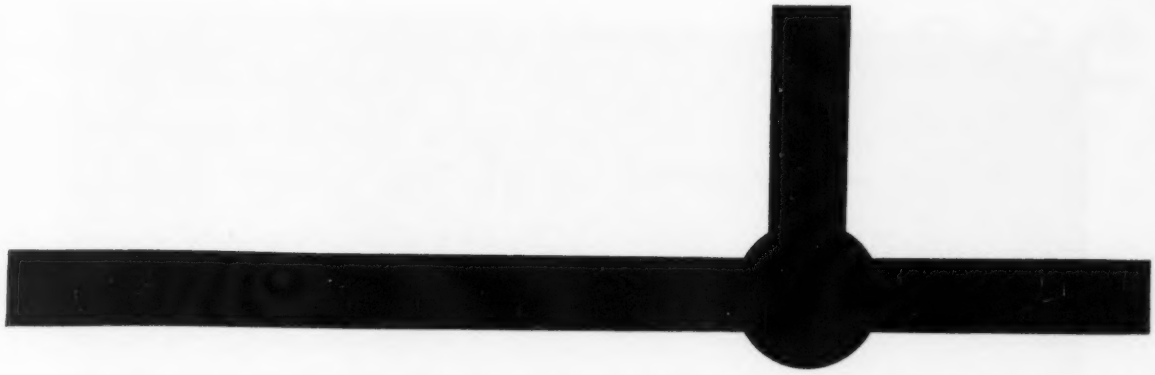
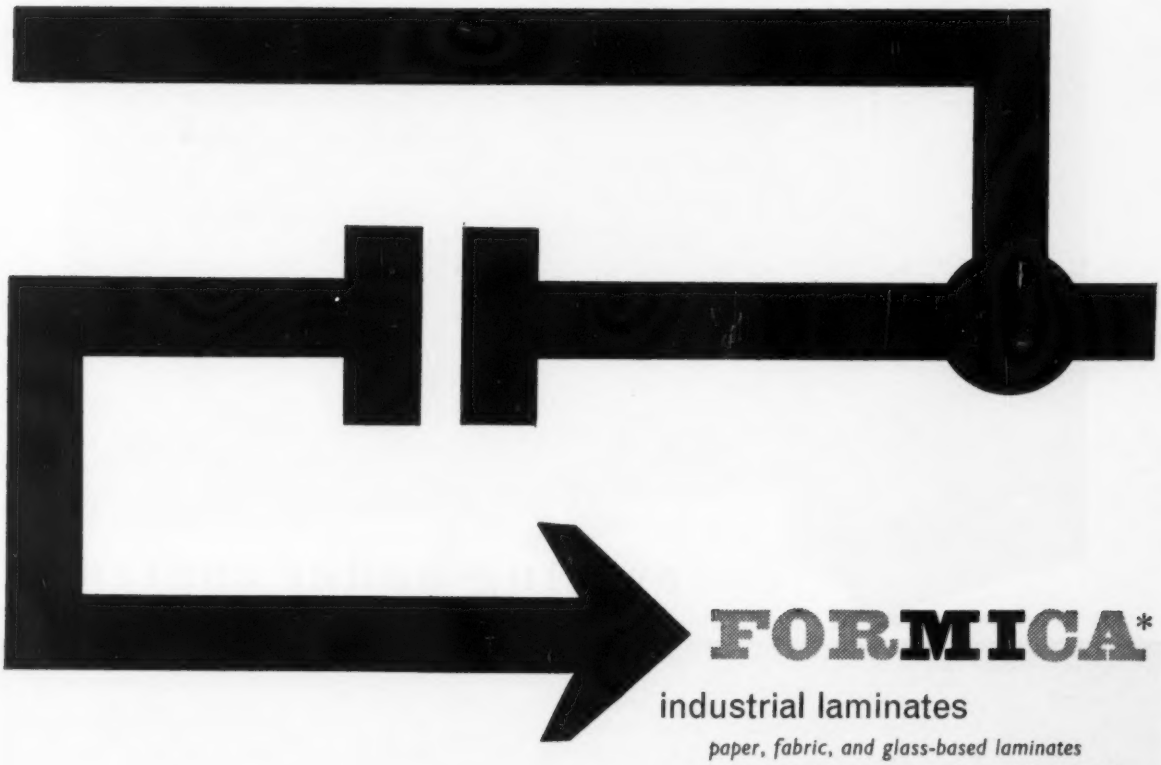


FORMICA for electrical insulation



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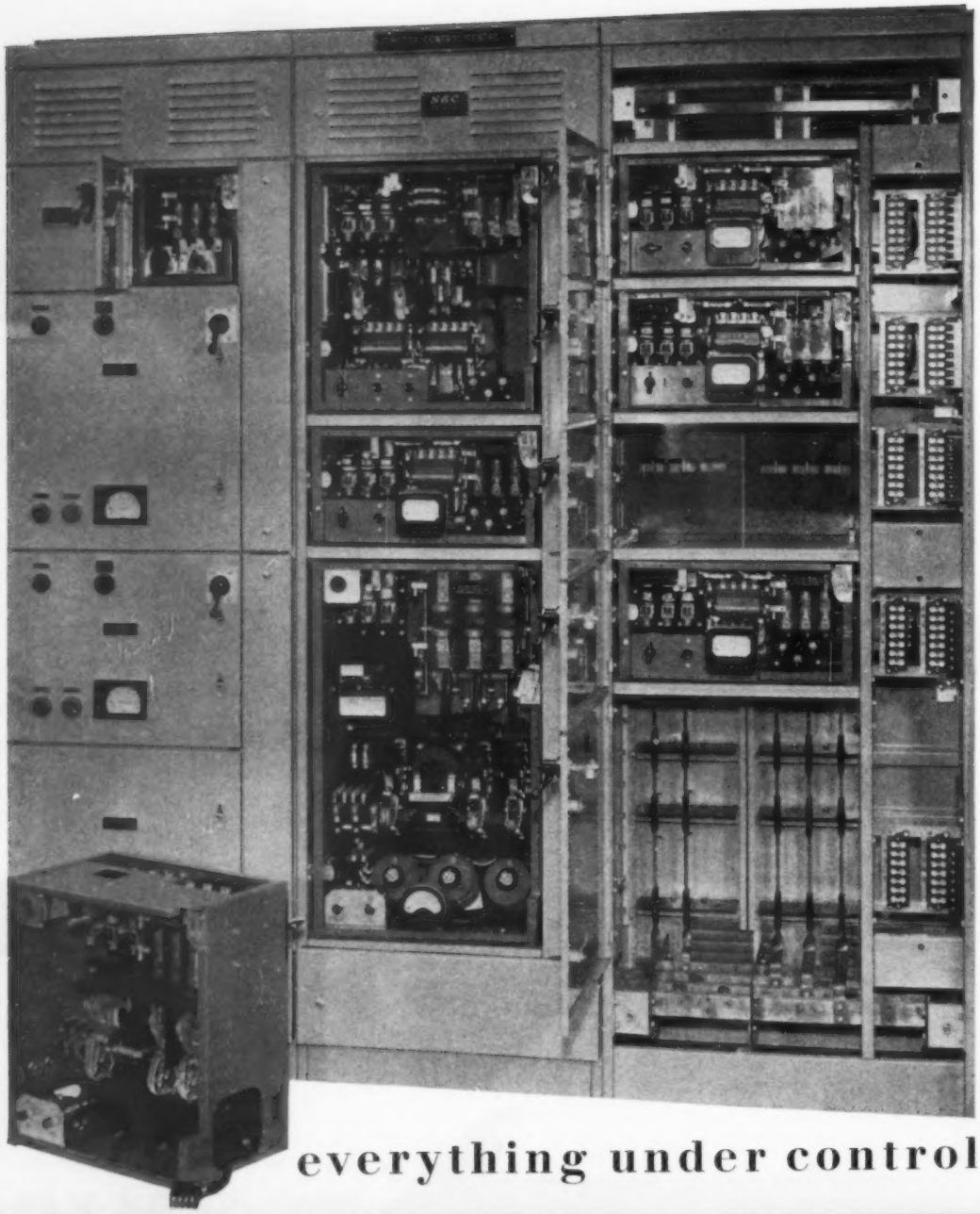

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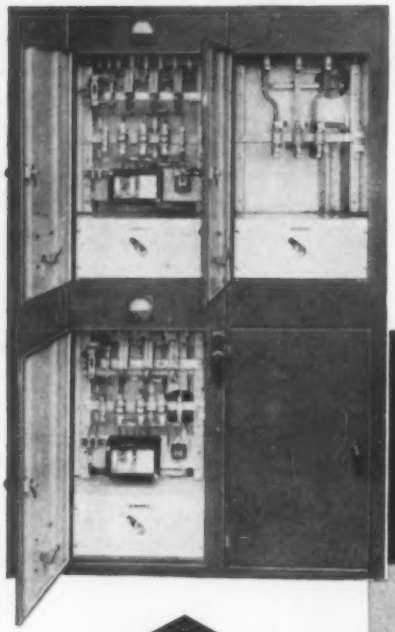
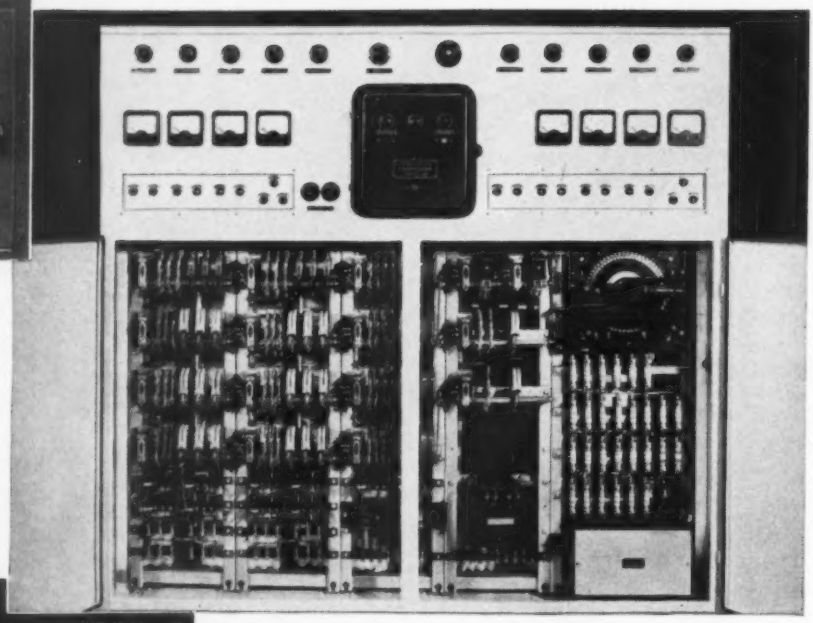
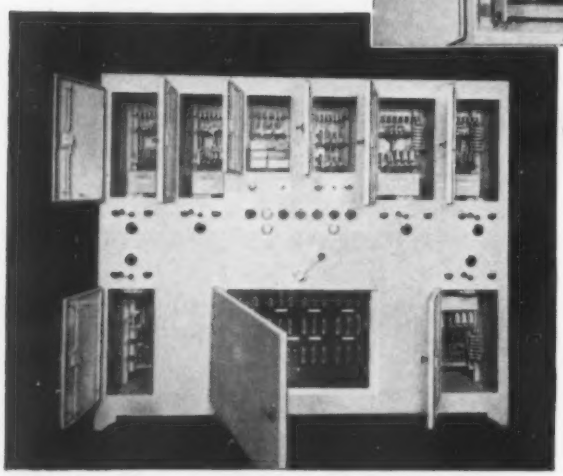


Two section, two-tier panel, one of a series supplied to a well-known paper manufacturing firm.



Multi-motor control panel with individual compartment and isolation for each motor starter, supplied to a large synthetic fibre manufacturing concern.



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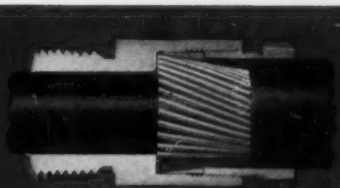

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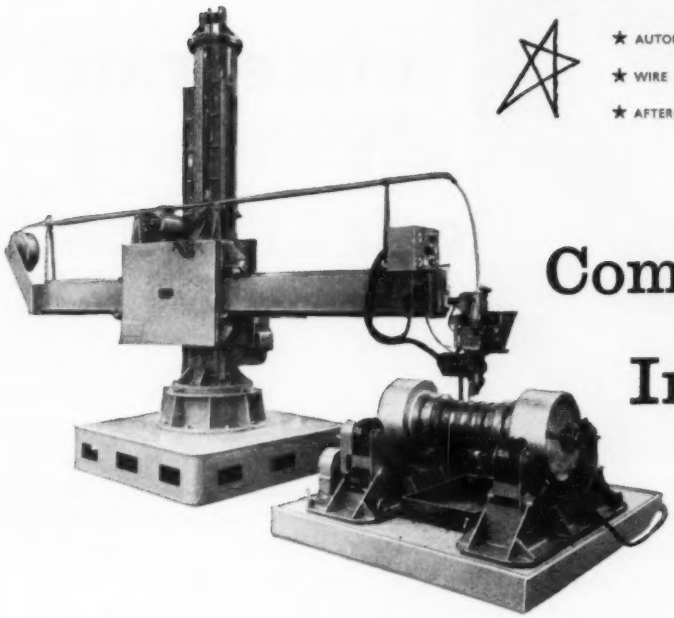
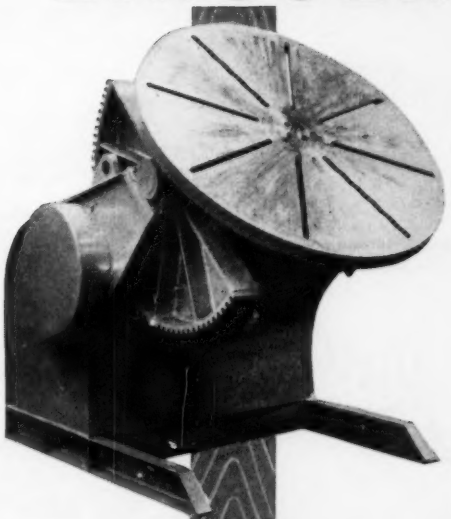
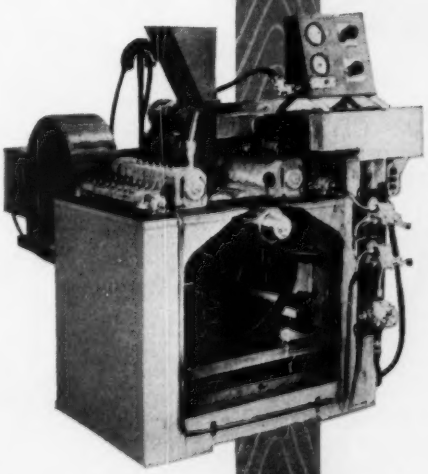


Complete Welding Installations by LINCOLN





For HIGH-SPEED production welding whether manual or automatic in application, LINCOLN offer a complete range of arc welding equipment and work handling fixtures, each installation being designed in close co-operation with your own engineering staff to ensure that it is individually fitted to your requirements.

Shown here is (above) a typical installation for pressure vessel and similar work incorporating the LINCOLN L.R.C. Revolving Column and Retractable Boom, a Fully Automatic LINCOLNWELD B.10 Submerged Arc Welding Unit, and LINCOLN L.S.A.R. Self-Aligning variable speed Rotators.

On the right is the LINCOLN 150 L.V.P. Variable Speed Positioner with a load capacity of 7½ tons, which is particularly suitable for heavy plate fabrication using either automatic or hand welding techniques. Shown below right is a LINCOLN Seam Welding machine incorporating a LINCOLNWELD M.L.3. Remote Control Automatic Submerged Arc Welding Unit.

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The Automatic Division

LINCOLN ELECTRIC

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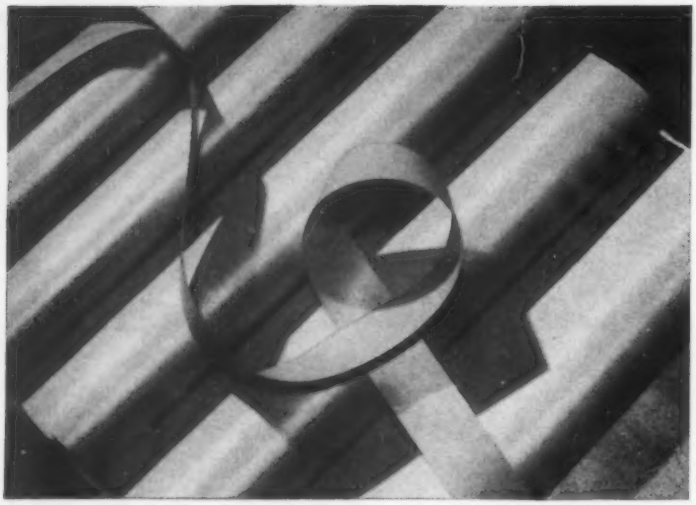
P.3



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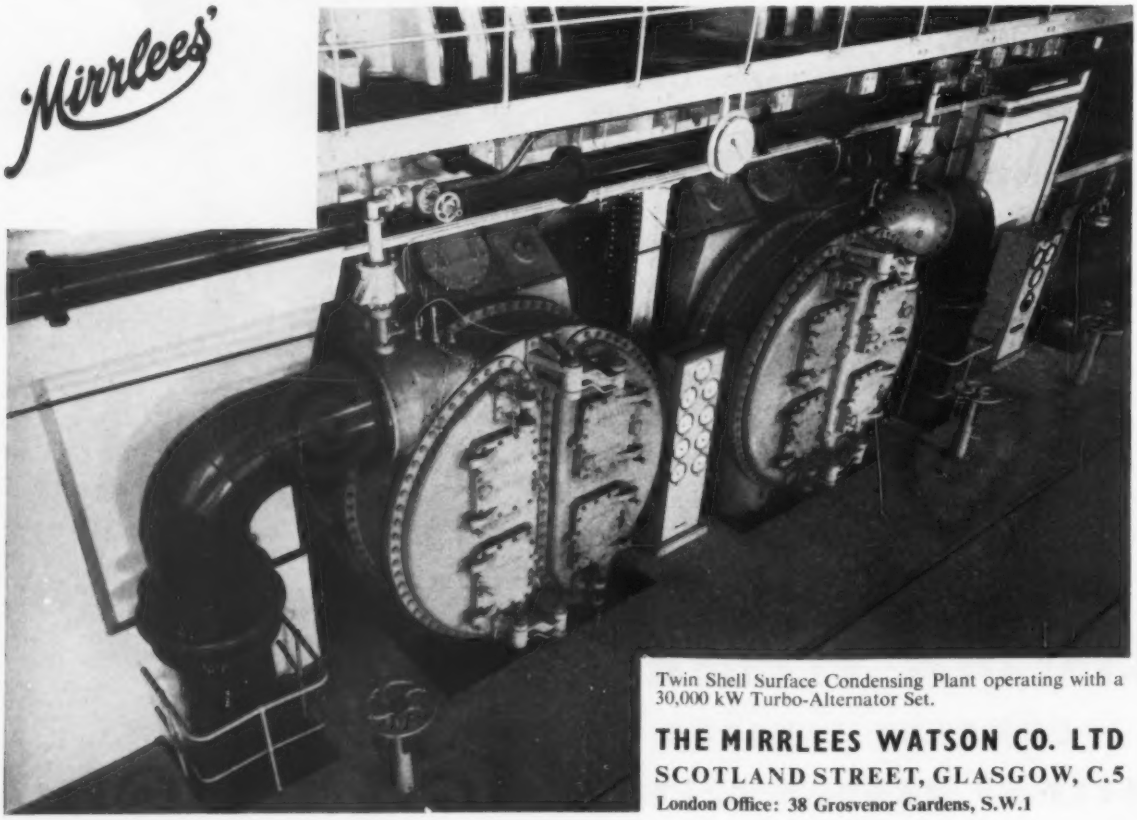
Mirrlees'



Twin Shell Surface Condensing Plant operating with a 30,000 kW Turbo-Alternator Set.

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SCOTLAND STREET, GLASGOW, C.5

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BASIC AID FOR AUTOMATION

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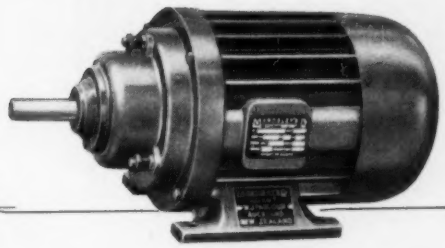
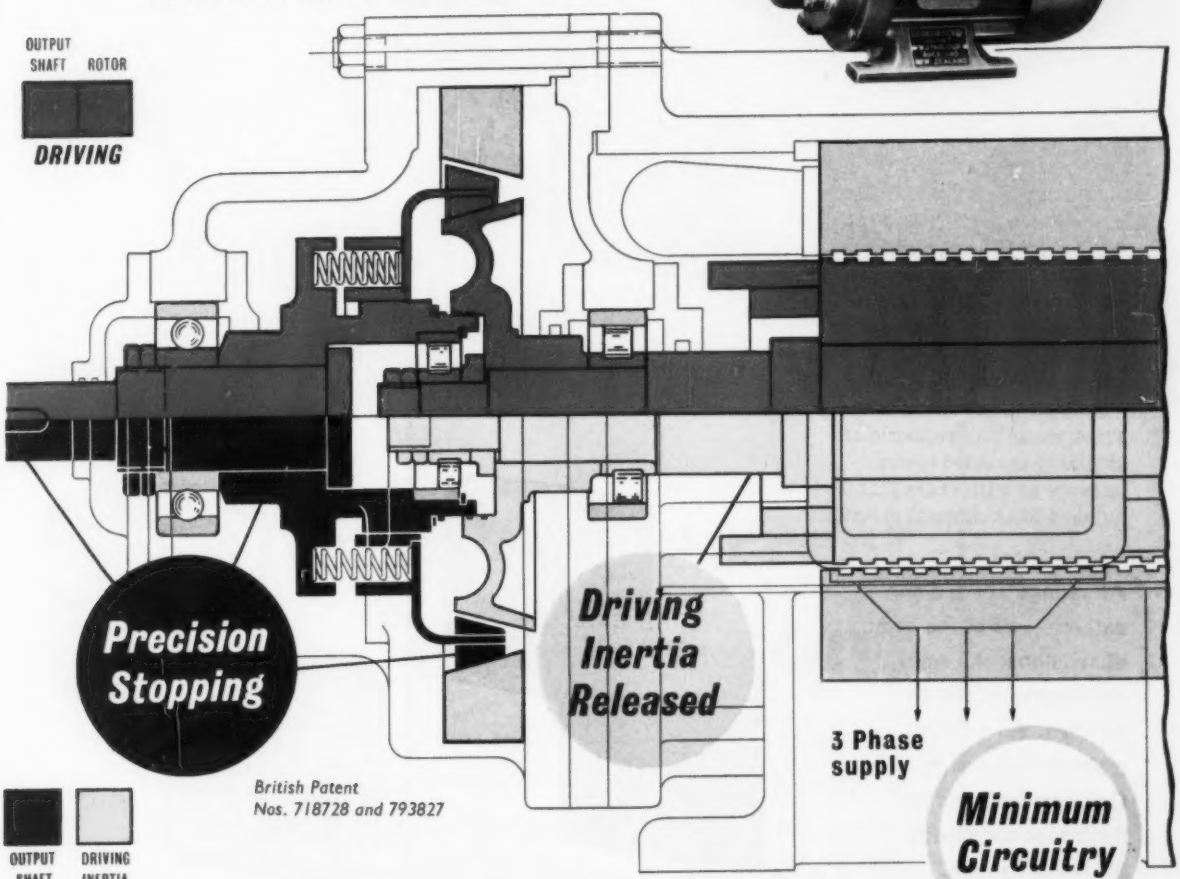
INTEGRAL A.C. MOTOR UNITS
CLUTCH/BRAKE ACTUATED BY ROTOR THRUST
WEAR ON LININGS COMPENSATED





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Full details on application

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MK161E DHB

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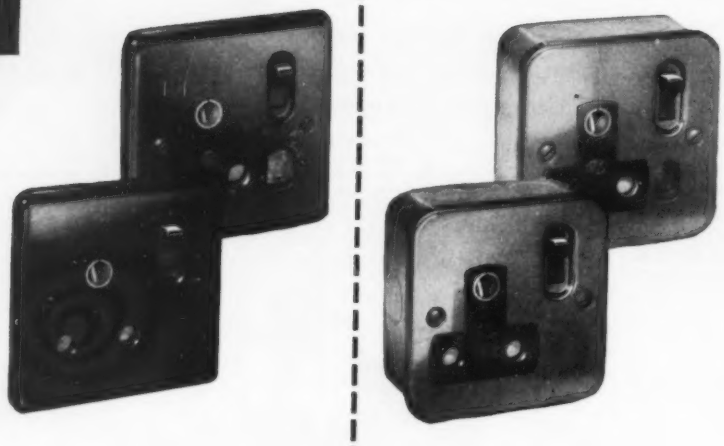
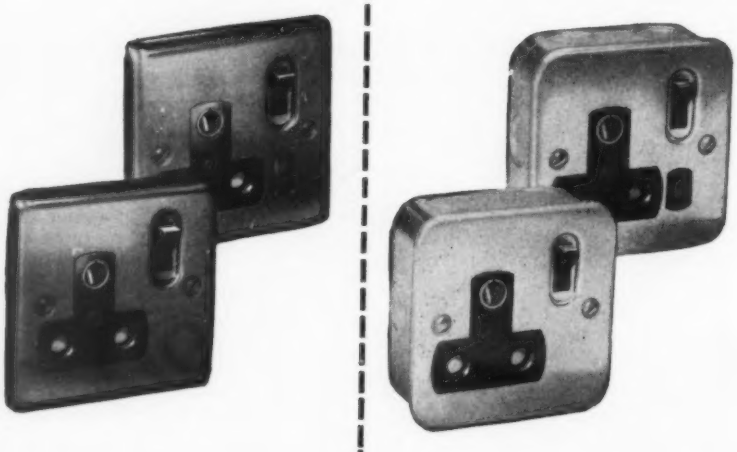


This versatile new range consists of interchangeable designs with standard 2¾" fixing centres. Flush patterns are therefore suitable for mounting in all standard boxes with 2¾" centres. This is a decided advantage enabling stocking, ordering, installation and maintenance to be simplified. Surface mounting units have steel plates finished aluminium stove enamel or brass plates finished BMA or matt chrome. Flush mounting patterns are available moulded brown or ivory or with brass plates finished BMA or matt chrome.



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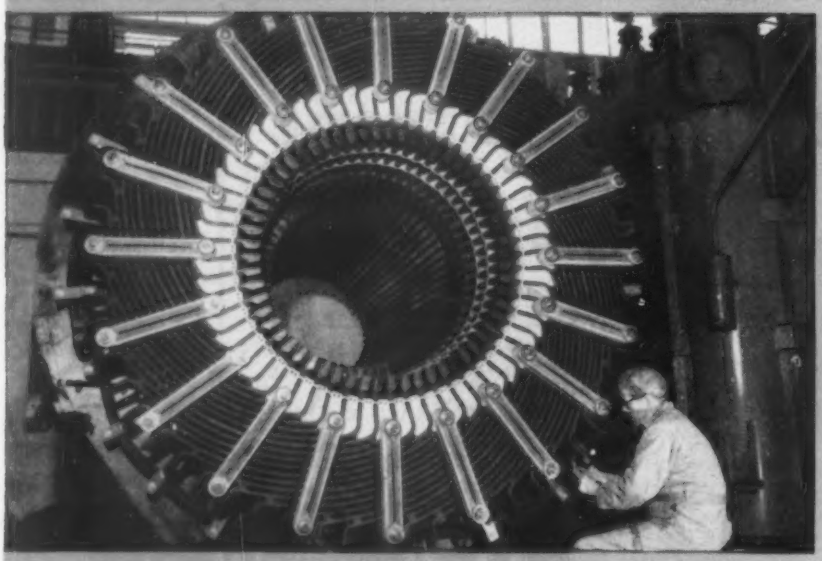

"PAXOLIN" and MICANITE are incorporated in the 23 MW air cooled turbo-generators at Chapel Cross Nuclear Power Station – another example of our service to the electrical industry.

Photographs:—(top) by courtesy of the U.K. Atomic Energy Authority. (lower) by courtesy of C. A. Parsons & Co., Ltd.

m and i the electrical insulation people

THE MICANITE & INSULATORS CO., LTD., Blackhorse Lane, Walthamstow, London, E.17

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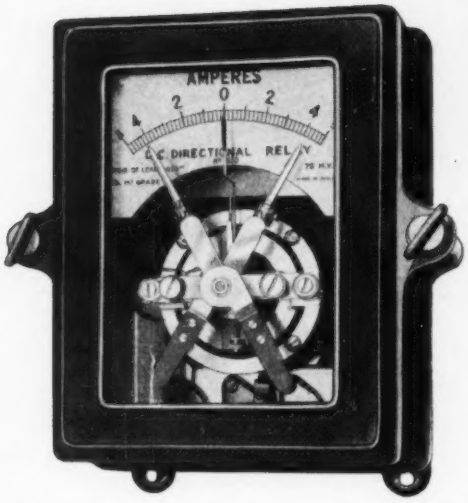

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For Control Systems where frequent operation is required relays can be supplied with electronic contact duty amplifiers.

Type LCT definite time relay with instantaneous reset.

Time settings adjustable up to 0/40 seconds. Operating coil wound for DC Voltage supplies Rectifier supplied for AC circuits.
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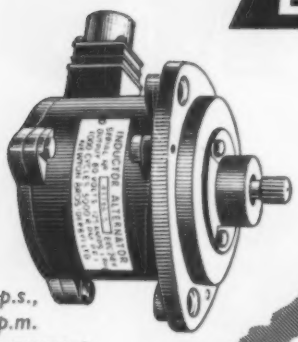

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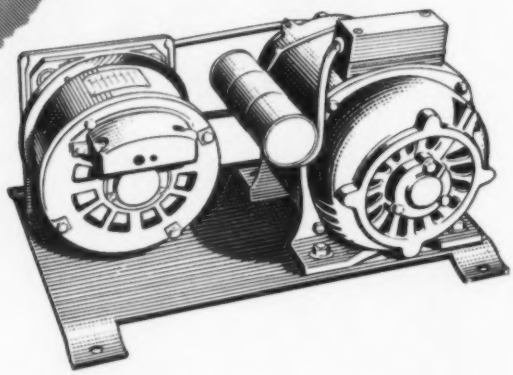
High Frequency Motor Alternator Set. 1 kVA, 115 volts, 1600 c.p.s., single phase



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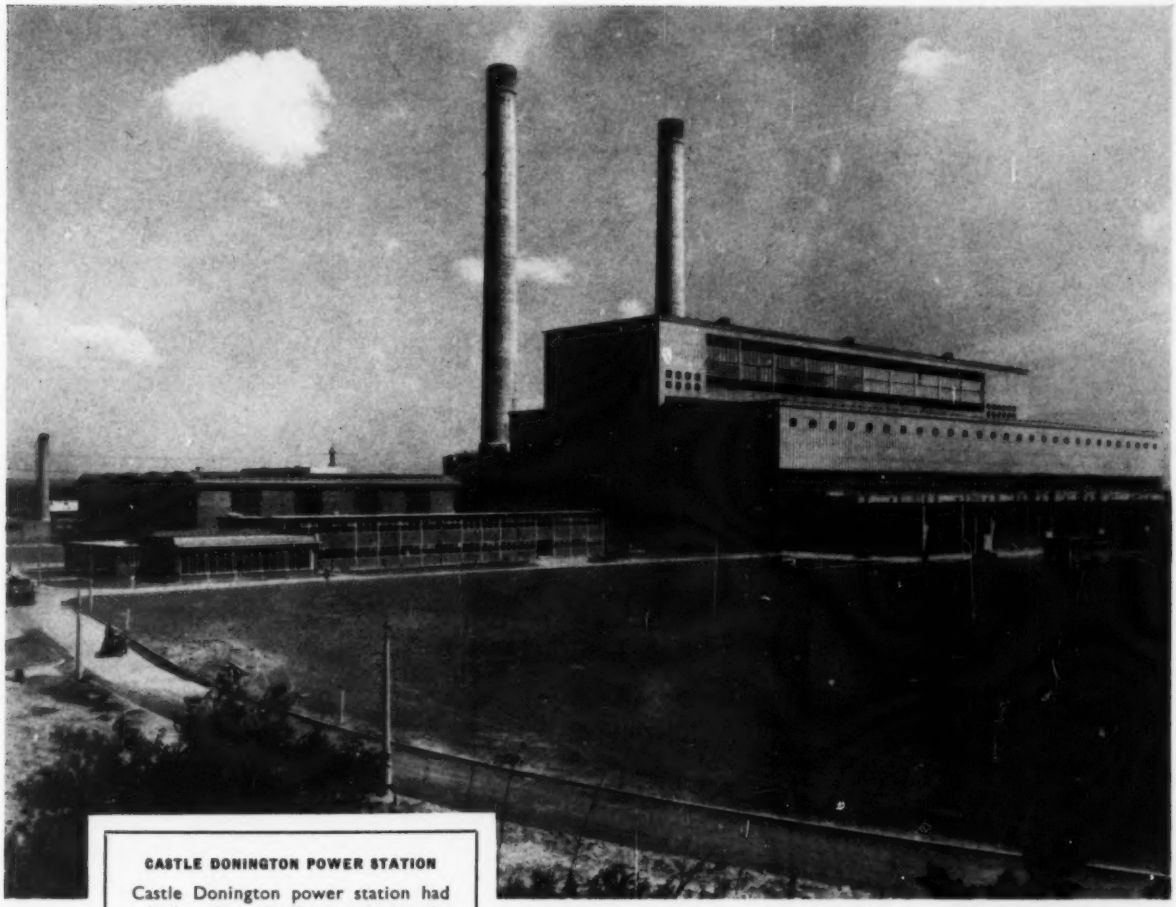

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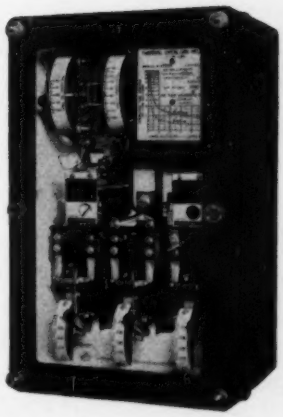

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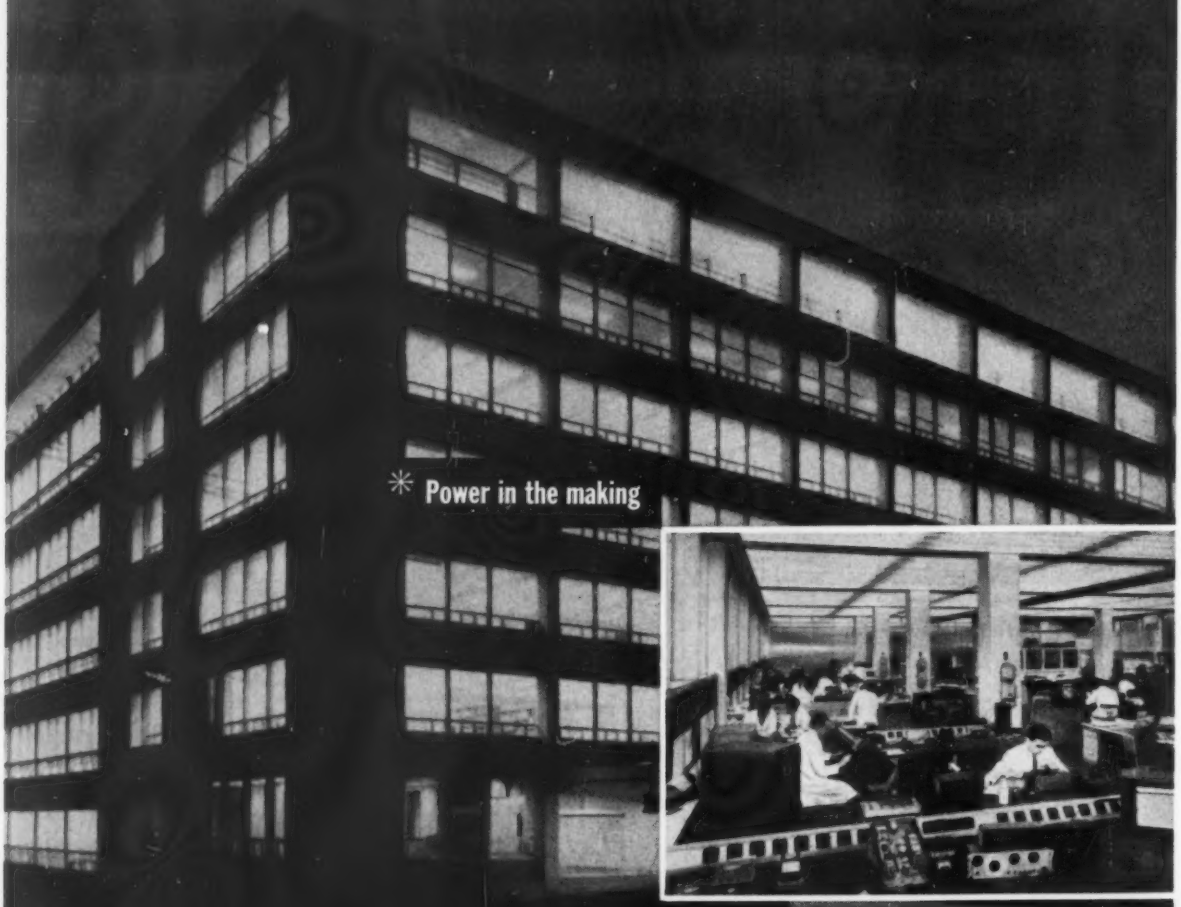

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✳ Research continues daily in metallurgy, steam, electrical generation, electronics, nucleonics, nuclear power and every field in the manufacture of power station plant. These are the tasks for scientific teams in the laboratories and research departments. At Heaton Works no effort is spared in the continued search for greater power and economy and here is seen the Research and Design Building. A new nuclear research centre will shortly be completed which will provide even greater resources.

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Up the carbon path...

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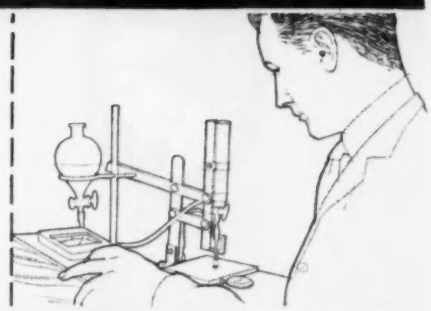

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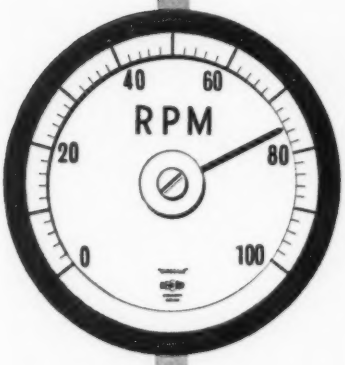

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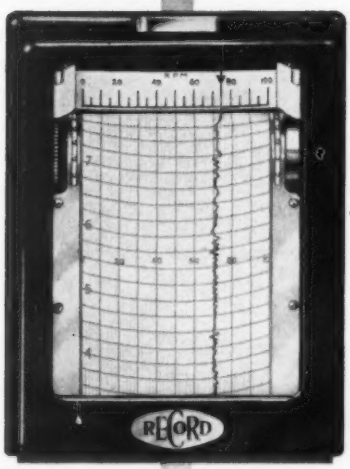

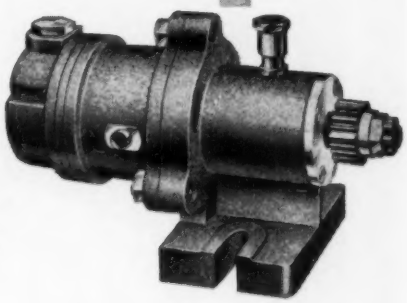

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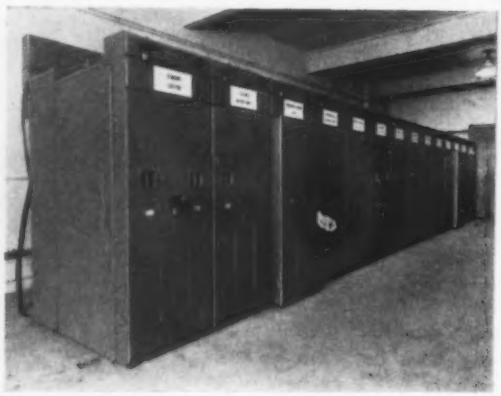

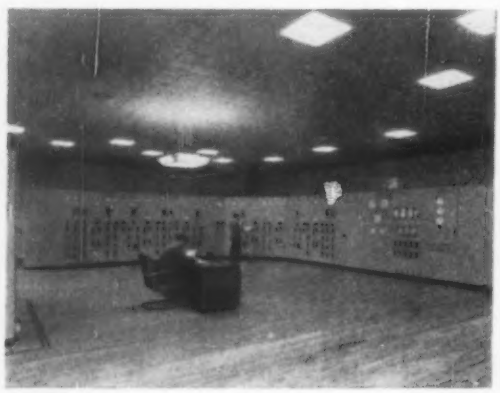

REYROLLE AT LACKENBY BEAM MILL

Illustrations show the main 11-kV 350-MVA oil-break switchgear, the 2.75-kV 150-MVA air-break switchgear, and the control-room in Dorman Long's new Beam-Mill at Lackenby.

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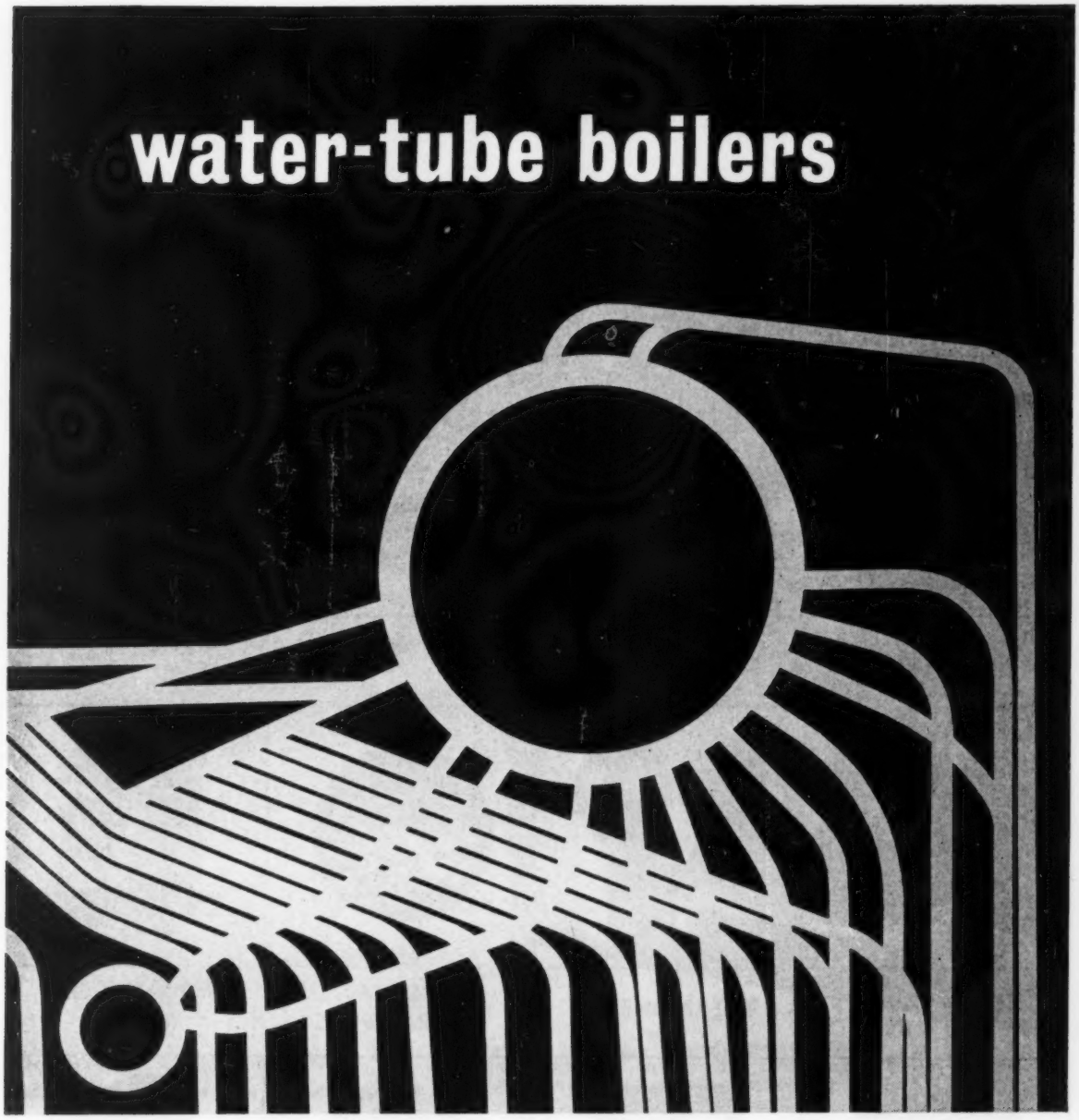
A. Reyrolle & Company Limited Hebburn - County Durham - England

water-tube boilers



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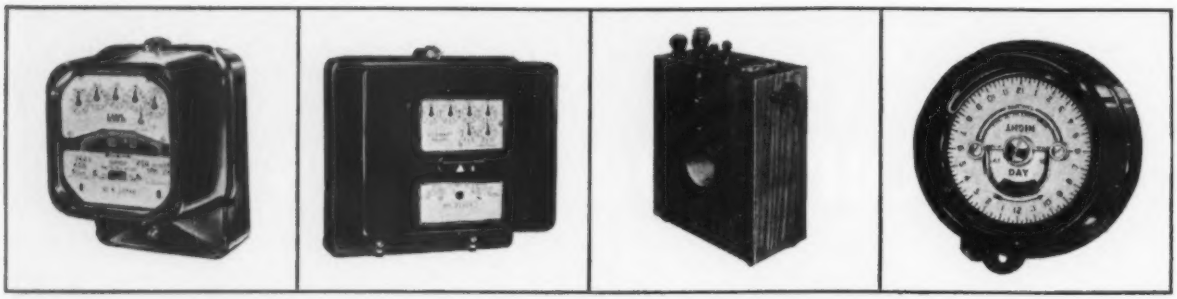

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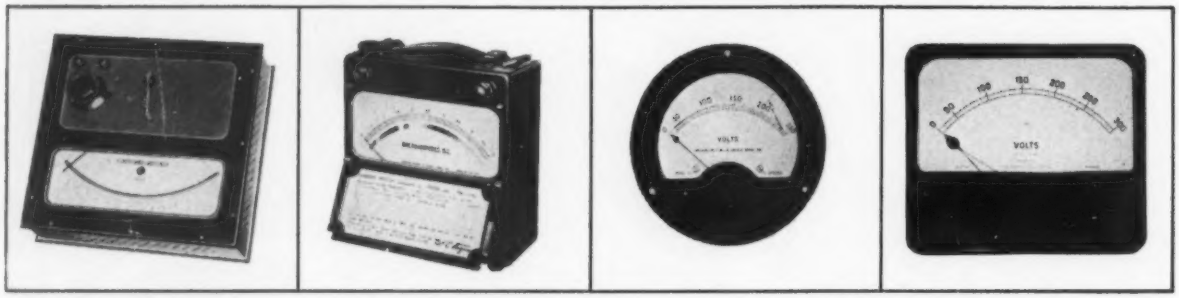

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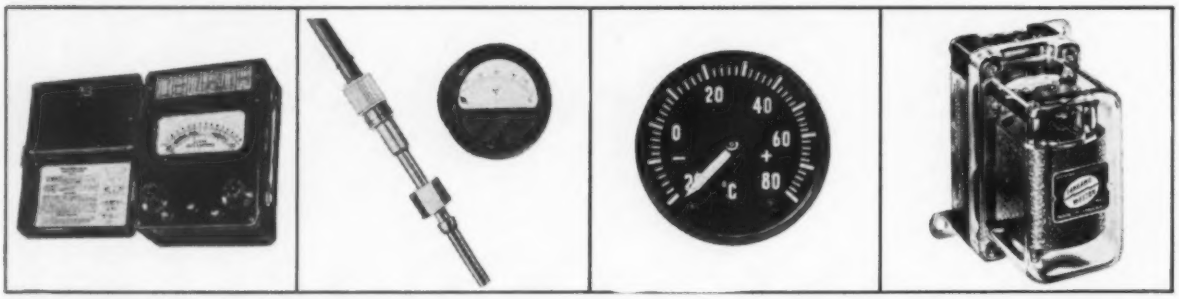
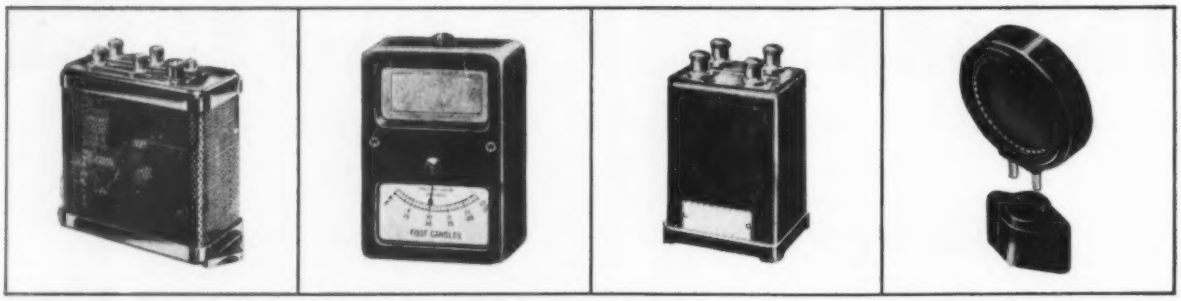


ALL-PURPOSE TEST INSTRUMENTS | THERMOMETRY | AIRCRAFT INSTRUMENTS | MOVING COIL RELAYS



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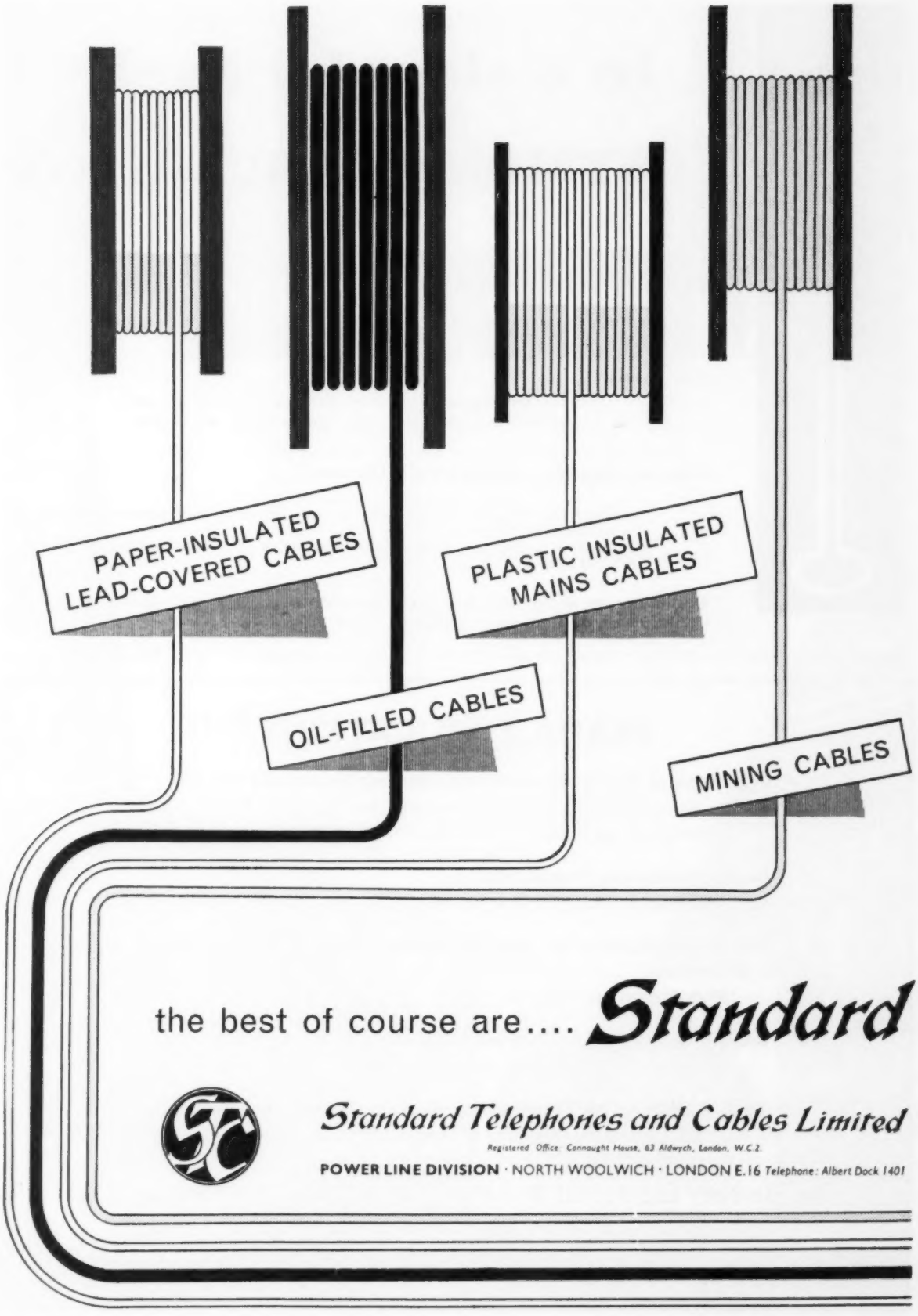

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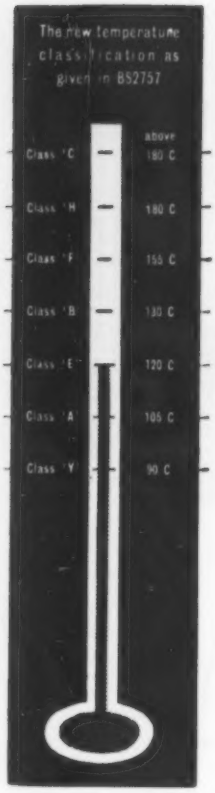
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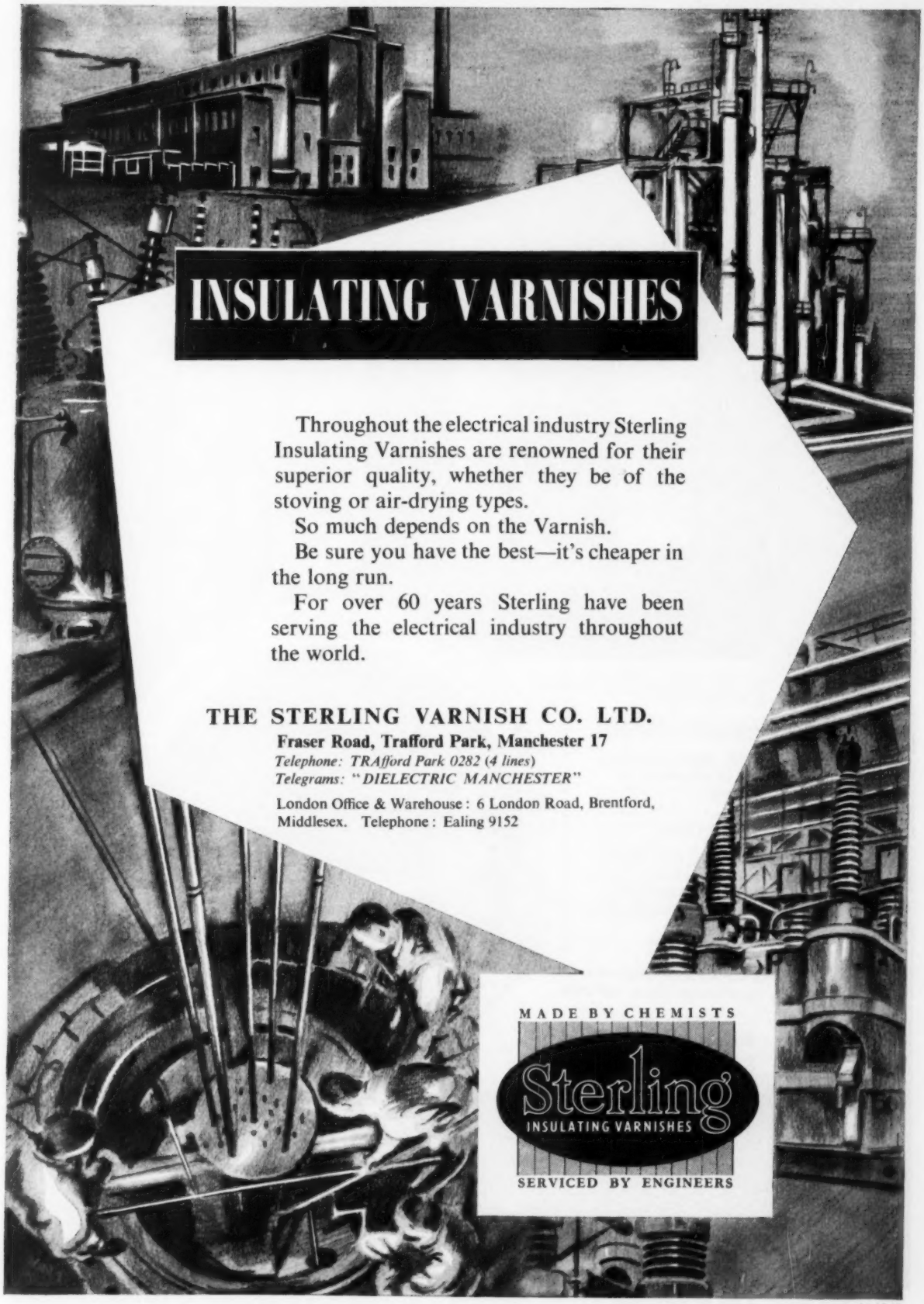
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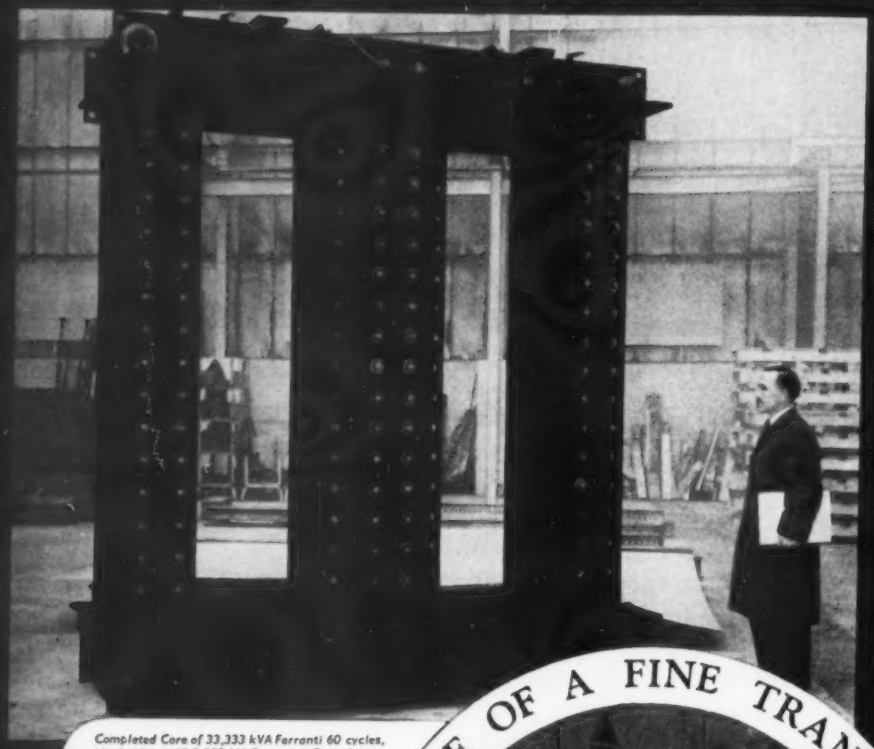

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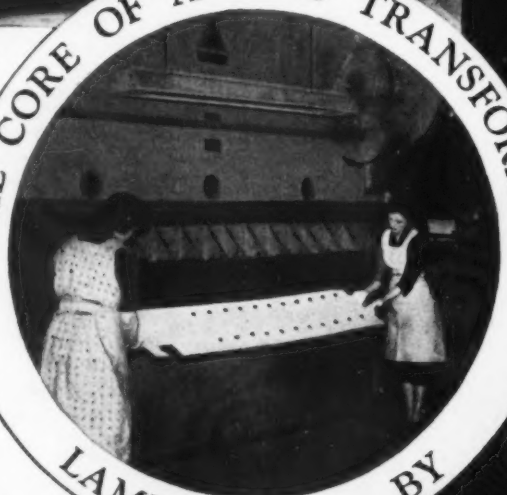

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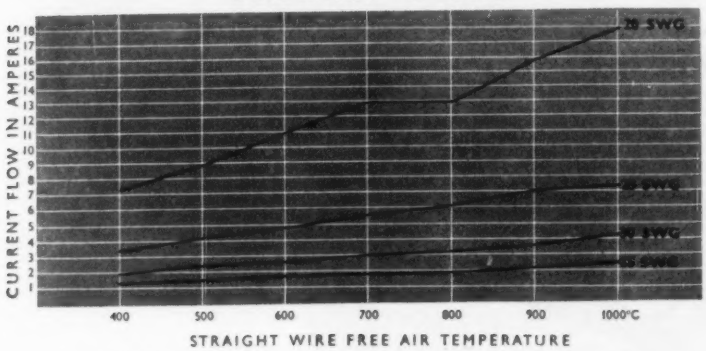

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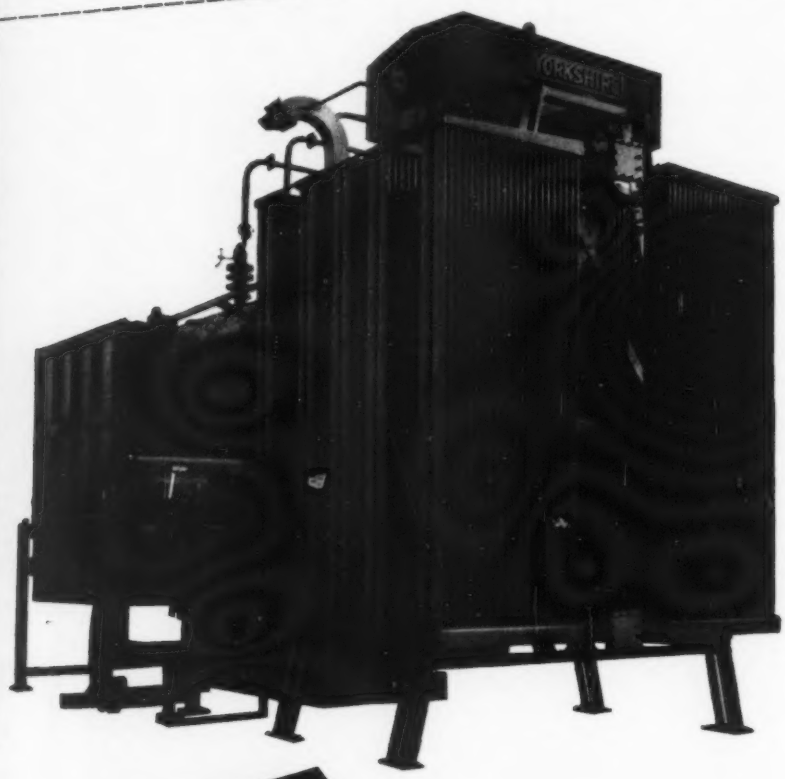

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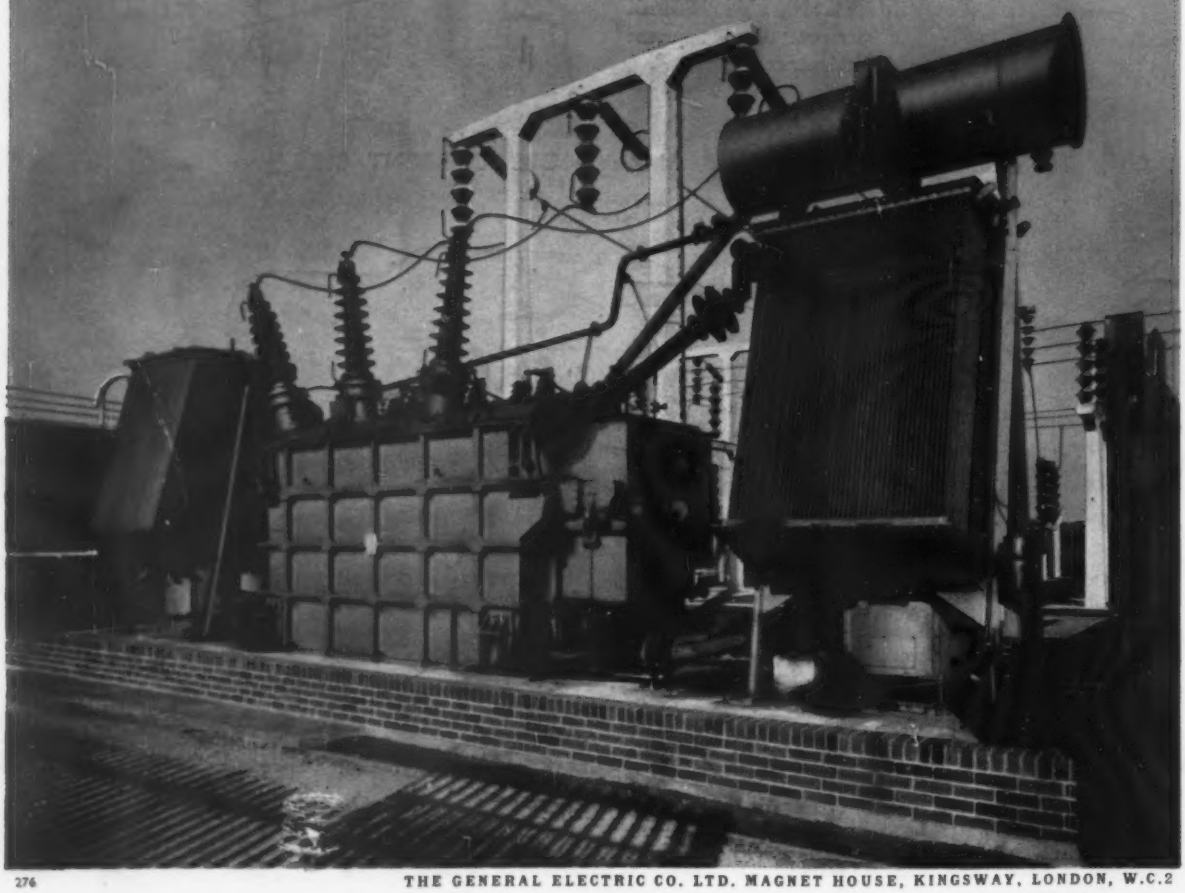

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